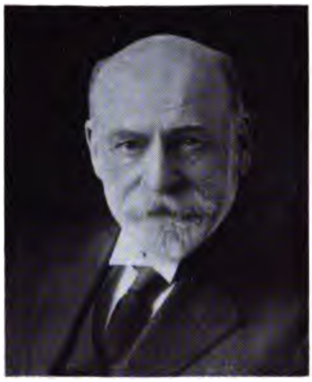

ANNUAL REPORT

UPON THE

GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN, IN CALIFORNIA, NEVADA, UTAH, ARIZONA, COLORADO, NEW MEXICO, WYOMING, AND MONTANA,

BY

GEORGE M. WHEELER,
FIRST LIEUTENANT OF ENGINEERS, U. S. A.;

BEING

APPENDIX FF

OF THE

ANNUAL REPORT OF THE CHIEF OF ENGINEERS FOR 1874.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1874.

[EXTRACT FROM THE ANNUAL REPORT OF THE CHIEF OF ENGINEERS TO THE SECRETARY OF WAR.]

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 20, 1874.

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GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN IN CALIFORNIA, NEVADA, UTAH, ARIZONA, COLORADO, NEW MEXICO, WYOMING, AND MONTANA.

Officer in charge, First Lieut. George M. Wheeler, Corps of Engi-

[Annual Report of Lieut. Wheeler, 1874.]

ERRATA.

Page 116, second paragraph, for Palaeosyopsos, read Palaeosyops.
Page 116, seventh paragraph, for medium, read median.
Page 118, third paragraph, for m.010, read M.010.
Page 118, eighth paragraph, for Ectoganus, read Esthonyx.
Page 123, fifth paragraph, for Hyposyus, read Hipposyus.
Page 123, eighth paragraph, for four molars, read three molars.
Page 124, eighth paragraph, for mandibular series, read preceding species.
Page 125, ninth paragraph, for sectional, read sectorial.
Page 128, seventh paragraph, for normal, read dermal.

lated and made available to the Government and the public.

By experience and improvements in methods and instruments, the value of the results is annually enhanced and the cost of the work amply repaid.

Final results in the astronomical and other branches of the work have appeared, and additional will be ready for the press and engravers before the close of the present year.

The expedition for the present field-season is well organized and equipped, and the officer in charge is sanguine of most satisfactory results. The field of operations lies in southern and southwestern Colorado, northern and northwestern New Mexico, and northwestern Ari-

[EXTRACT FROM THE ANNUAL REPORT OF THE CHIEF OF ENGINEERS TO THE SECRETARY OF WAR.]

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 20, 1874.

* * * * * * *

GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN IN CALIFORNIA, NEVADA, UTAH, ARIZONA, COLORADO, NEW MEXICO, WYOMING, AND MONTANA.

Officer in charge, First Lieut. George M. Wheeler, Corps of Engineers, having under his orders First Lieuts. R. L. Hoxie, W. L. Marshall, S. E. Tillman, and P. M. Price, Corps of Engineers, Second Lieut. A. H. Russell, Third United States Cavalry, and, during portion of the field-season, Lieuts. H. R. Brinkerhoff and L. H. Walker, Fifteenth United States Infantry, as escort officers, Acting Assistant Surgeons J. T. Rothrock, H. C. Yarrow, and C. G. Newberry, United States Army, who, in addition to their professional duties, were engaged in botanical, ornithological, and natural-history labors.

Active field-operations were in progress at the commencement of the fiscal year, the three main divisions of the expedition having departed from their rendezvous at Salt Lake City, Utah, Denver, Colorado, and Santa Fé, New Mexico, moving south into Arizona, connecting with work of former years, covering during the season an area of about 75,000 square miles, and disbanding at the close of the field-season in November and December.

Following the disbanding a sufficient number of the members to prepare the matured results returned to Washington, where they were engaged during the winter months, and where a small force of draughtsmen and computers are continuously engaged in elaborating the material gathered in the field.

In addition to topographical work proper the survey combines the establishment of numerous points astronomically; (an important feature in relation to many public and private interests;) observations in meteorology and hypsometry; investigations in geology, mineralogy, and natural history; and the gathering of many other facts upon subjects bearing upon the industries and resources of the regions traversed. A mass of useful information and results is thus constantly being accumulated and made available to the Government and the public.

By experience and improvements in methods and instruments, the value of the results is annually enhanced and the cost of the work amply repaid.

Final results in the astronomical and other branches of the work have appeared, and additional will be ready for the press and engravers before the close of the present year.

The expedition for the present field-season is well organized and equipped, and the officer in charge is sanguine of most satisfactory results. The field of operations lies in southern and southwestern Colorado, northern and northwestern New Mexico, and northwestern Ari-

zona. Several primary astronomical stations will be determined in addition to astronomical observations in the field, and the astronomical observatory at Ogden, Utah, will be well advanced toward completion.

Lieutenant Wheeler submits estimates —

For continuing the exploration	$95,000
For engraving and printing the plates and atlas-sheets accompanying the reports of the geographical explorations and surveys west of the 100th meridian	25,000

His annual report and estimates are appended.

(See Appendix FF 1 and FF 2.)

Lieutenant Wheeler has also submitted a report of Prof. E. D. Cope, paleontologist, from his camp, on Galinas Creek, in the Rio Grande basin, including a description of new species of vertebrate fossils, and of an extensive series of deposits of the Eocene age, indicating the existence, in earlier geological time, of an extensive lake of fresh water in that part of New Mexico.

The collections made and to be made by this special party are likely to prove of unusual interest.

(See Appendix FF 3.)

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REPORT.

APPENDIX FF.

ANNUAL REPORT OF LIEUTENANT GEORGE M. WHEELER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1874.

GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN, IN CALIFORNIA, NEVADA, UTAH, ARIZONA, COLORADO, NEW MEXICO, WYOMING, AND MONTANA.

Season's operations.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS
WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., June 30, 1874.

GENERAL: I have the honor to submit the following annual report upon geographical explorations and surveys west of the one hundredth meridian, in California, Nevada, Utah, Arizona, Colorado, New Mexico, Wyoming, and Montana for the fiscal year ending June 30, 1874.

Toward the close of the last fiscal year, the expedition of 1873 had taken the field in three separate divisions from Salt Lake City, Utah, Denver, Col., and Santa Fé, N. Mex.

The Salt Lake division, under Lieut. R. L. Hoxie, Corps of Engineers, crossed the Colorado River near the mouth of Paria Creek, emerging upon the mesa to the southward, in the vicinity of El Vado de los Padres; from thence making its way to the southward, joined the southern or main division, operating in the territory in New Mexico and Arizona but little known, lying between the thirty-fifth and the thirty-second parallel after it had completed the duties assigned to it in atlas rectangles 50 and 59.

Each division was accompanied by a small escort. These escorts were (with the exception of one corporal and six men, with Lieutenant Hoxie, detailed from the military department of the Platte, General E. O. C. Ord commanding) drawn from the military department of the Missouri, General John Pope commanding, the larger portion of the latter having been detailed from the military district of New Mexico, Col. J. Irwin Gregg commanding. These escorts were distributed among the several working field-parties, and were in numbers sufficient only for the protection of the lives of the members of the expedition and for guarding the public property. The necessary number of guides, packers, herders, laborers, &c., accompanied the expedition.

The Denver division, or Colorado party, under Lieut. W. L. Marshall, Corps of Engineers, was occupied for the entire season in Colorado, and completed most successfully the duties assigned to it in that field.

Executive reports submitted by Lieutenants Hoxie and Marshall are herewith.

Report of Lieut. R. L. Hoxie, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS
WEST OF ONE HUNDREDTH MERIDIAN,
Washington, D. C., January 1, 1874.

SIR: I have the honor to submit the following executive report of operations under my charge during the field season of 1873:

The party to which I was assigned as executive officer in charge was organized at Salt Lake City, Utah, and consisted of Gilbert Thompson, topographer; Edwin E. Howell, geologist; William Somers, meteorologist; Alexander Brown, odometer recorder; one cook, one cargadore, and four packers, with an escort of one sergeant and five privates from the military Post of Beaver, Utah.

The party left Salt Lake City on May 30th, and operated, until September 7th, east of the Wahsatch Mountains, in Castle Valley, working its way southward to the Colorado River, over the western part of Castle Valley, the portion of country required to complete atlas sheets Nos. 50, 59, and 67, at that time preparing for publication.

On the 7th of September we crossed the Colorado River and proceeded by way of Oraybe and the Moquis Pueblos to Fort Wingate, N. Mex., whence, after refitting, we proceeded southward, co-operating with the other parties in New Mexico and Arizona Territories, and, returning at the close of the season, disbanded at Fort Wingate on the 25th of November.

During the three months' operations in Utah about fifteen hundred topographical and triangulation stations were occupied, and one thousand and twenty-five miles of meander lines measured, besides which numerous detours were made for the ascent of prominent points as triangulation stations. The latitude and departure of camp was computed each night, the meander lines of the day plotted, and the principal topographical features drawn upon the field-map. Sextant observations for latitude upon north and south stars, and observations on Polaris for magnetic declination, were taken at each camp. The meridian of Provo was connected with that of the observatory at Salt Lake City, time-signals having been sent over the wires of the Deseret Company, freely tendered to the expedition by the courteous action of D. Milton Musser, superintendent.

The cistern and aneroid barometers, with the psychrometer, were read at regular intervals in camp and at all points that would serve to indicate the relief of the country.

About six thousand square miles of a very difficult mountain and cañon country was mapped here.

The accuracy of the work depends upon the triangulation and the latitude-checks. The former was entirely upon natural objects, the peaks of the Wahsatch range, the Henry Mountains, Navajo, and prominent mesas, and made with the gradienta by Mr. Thompson, who has shown more than ordinary skill and energy in performing rapid and accurate work. We derived much assistance from Mr. Howell, whose investigations in geology were necessarily carried on in intimate connection with the topography.

The sextant observations were made entirely by myself, and the average probable error of the results is about ten seconds of arc.

More time was taken in this part of our field of operations than allowed by your instructions, but this was necessitated by the obstacles encountered. In the month of June we found the high passes of the Wahsatch Range blockaded with snow and mud, and the streams on the eastern slope were swift, cold, and deep, causing serious detentions.

Later in the season we had worked our way southward into the cañon country, in which progress was necessarily slow, and a scarcity of grass and water added to the difficulty of traversing the country. At this time two of my packers deserted with thirty-two mules, and caused a further delay of about twenty days. The time was usefully employed, however. The full working force kept the field as usual, and although I had not intended to give the time here, the work done in consequence could not well have been dispensed with. The recovery of the mules, with the men who ran them off, cost me a chase of four hundred miles, the return being accomplished in two hundred more, over the wildest part of a difficult country.

We encountered considerable hardship during this part of our season's work, being frequently without good water, and sometimes without any. At one time we subsisted for seven days upon hard corn, brought along for the mules, and taken from them when they could ill spare it.

It was not possible to sacrifice close work to the pressure of time, as the devious track which covered so much ground was forced upon us by the difficult nature of the country.

A portion of the results of this part of the season's work are already published in Atlas sheets Nos. 50 and 59, and Mr. Howell will report upon the geology and mineralogy of the country so far as observed by him.

From the crossing of the Colorado to Fort Wingate, the most direct route was taken and no attempt was made to map the country through which we passed. The trail was carefully meandered, however, the topography adjacent sketched in, and frequent bearings taken as checks upon prominent points, with the usual latitude-checks for the camps and the observations with cistern barometer, aneroid, and psychrometer. The primiary object here was celerity of motion, the survey recommencing at Fort Wingate. The length of measured meander line was about two hundred miles.

Soon after leaving Fort Wingate Mr. Thompson was detached by your order, with a small party, to carry a system of triangles over the ground covered by my own and the other parties then operating together in New Mexico. This work was successfully accomplished. Base lines

were measured at Fort Tulerosa and Fort Bayard, and others located to be measured next season.

The work of my own party in this section of the country was conducted in the same manner as in Castle Valley during the earlier part of the season; but, having much more favorable conditions, better results were obtained.

About five thousand square miles were covered along the Atlantic and Pacific divide, in the section of country embraced in Atlas sheets Nos. 76, 83, 77, and 84.

This has been mapped and is ready to be transferred to the Atlas sheets.

Detailed reports of the geology and mineralogy of the region traversed will be submitted by Mr. Howell and Dr. Oscar Loew.

Very respectfully, your obedient servant,

R. L. HOXIE,
Lieut. of Engineers, U. S. A.

Lieut. GEO. M. WHEELER,
Corps of Engineers, U. S. A.

Report of Lieut. W. L. Marshall, Corps of Engineers.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS
WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., June 30, 1874.

SIR: I have the honor to submit the following executive report of the operations of the Colorado party of the expedition for explorations and surveys west of the one hundredth meridian, during the field season of 1873.

In accordance with the annual project, approved by the Secretary of War and Chief of Engineers, and pursuant to instructions from you, I organized the party at Denver, Colo., about June 1, 1873. Its *personnel* was as follows: First Lieut. W. L. Marshall, United States Engineers, executive officer and astronomer; Dr. J. T. Rothrock, acting assistant surgeon, United States Army, surgeon and naturalist; Prof. J. J. Stevenson, geologist; J. J. Young, topographer; Edgar Schroeder, assistant topographer; Prof. John Wolf, collector in botany; Bernard Gilpin, meteorologist, and a small escort of enlisted men from the Fifth Infantry. Including packers and employés the party numbered forty-two men. Later in the season we were joined by Mr. Louis Nell, chief of triangulation. Pending the organization of the main party, on the 8th day of June a small topographical party was sent out to define the bases of the mountains, or "hogsbacks," from the mouth of the Platte Cañon to Golden City, with orders to join the main party at Georgetown, Colo., on the 16th.

On the 17th of June, having received at Georgetown the necessary supplies, I sent the main party, under Dr. Rothrock, to encamp near Fair Play, in South Park, to allow the collectors in natural history an opportunity to make full collections in the several branches in that vicinity, and to establish a meteorological station at the permanent camp. My small party retraced their course to Idaho Springs, visited the mines at Central City and Black Hawk; thence, by way of Chicago Lake and Mount Evans, to Georgetown, making the necessary topographical stations. On June 22 the Atlantic and Pacific divide was crossed

at the Argentine Pass, and from this date to July 4 the party worked about the heads of the Blue and Platte Rivers, in the cross range between Middle and South Parks, and in the Blue River range, making the ascent of Lincoln Peak and such other stations as were necessary to give a knowledge of the topography of this region.

Leaving the collecting party at Fair Play with orders to move camp to Twin Lakes, on the west side of the Upper Arkansas River, by August 1, the field party proceeded to survey the mountain-ridges bounding South Park, examined the country about the heads of the North Fork of the South Platte; the Kenosha range from Mount Evans to the Platte and Arkansas divide; this divide from the southeastern limit of South Park to the head of the South Fork of the South Platte River, meandering en route the principal roads and streams, and making the necessary stations upon mountain-peaks to check by triangulation the principal points of the survey. Wet Mountain Valley was visited, and the Arkansas River traced from near Cañon City to Granite C. H., at which place we arrived August 1, 1873.

During this interval, July 5 to August 1, Mr. Schroeder was employed with a small topographical party in collecting topographical data and in meandering roads and streams in South Park not traced upon the plats of the General Land-Office, and not visited by my own party.

From the non-arrival of supplies forwarded by the Quartermaster's Department from Cheyenne, a delay of several days was necessitated, which interval was spent in the immediate vicinity of Twin Lakes in collecting topographical details. A base was measured and an accurate trigonometric survey of the lakes made, and the topographical features relatively located from it. Two lines of soundings across either lake were made at the request of Prof. Stevenson.

On the 6th of August, having purchased the necessary supplies, the geologist and topographer were sent to visit the mines at Oro City, Colo., and McNutty gulches, and Homestrike Mountain, and to examine the country about Ten-Mile Creek, one of the tributaries of the Blue River; the western slope of the Blue River range; to meander Eagle River and its main branches, and to define the northern limit of the main or Saguache range west of the Arkansas River.

This party having accomplished its object, returned to the permanent camp at Twin Lakes on August 18. On the following day, still leaving the collecting party at Twin Lakes with facilities to extend the field of their investigation wheresoever they pleased, two topographical parties were dispatched—Mr. Schroeder, assistant topographer, to collect topographical data and meander the streams flowing into the Arkansas north of Lake Creek; to fix the water-shed and locate the heads of the middle branch of the Roaring Fork of the Grand River; while my own party crossed the divide at the head of Lake Creek, and from August 19th to September 3rd were engaged about the heads of the Gunnison River, and the southern tributaries of the Roaring Fork of the Grand River stations were made upon prominent peaks in the Elk Mountains, and also in the Saguache range at the heads of Chalk and Cottonwood Creeks, and the cañon of Taylor River traced to the junction of this stream with East River.

On the 3d of September the party was joined by Mr. Nell, chief of triangulation, from Fort Wingate, N. M.

On September 5th, he was sent with orders to make triangulation-stations near the junction of the Eagle and Grand, at the northern extremity of the Saguache range, in the Blue River range, upon Gray's Peak and Mount Evans, connecting the former with the astronomical

point at Georgetown; thence to proceed by the shortest road to Pike's Peak, which point had been located from a base measured near the astronomical station at Colorado Springs by Dr Kampf, making secondary stations *en route;* thence *via* the southern rim of South Park and the Platte and Arkansas divide to South Arkansas Creek, and thence to Fort Garland, making the necessary stations to give a connected system of triangles from the northern to the southern limit of our survey; from which points those occupied by Messrs. Young and Schroeder could be fixed. These orders were carried out by Mr. Nell, except that he was prevented by snow from actually occupying one of the main stations near the head of the South Arkansas, suggested to him. This point, though quite accurately fixed in longitude and latitude, must be occupied the coming season.

From September 5 to October 10 two parties were continuously employed in completing the survey of the drainage-areas of the upper Arkansas, and that part of the area drained by the Gunnison River which lies east of the one hundred and seventh meridian. From the 10th of October to November 4 a line-survey was run up the valley of the Rio Grande River to the San Juan mining district, but snow, which fell to the depth of 13 inches on the 15th, 16th, and 17th of October, prevented any further work in this region at high altitudes and effectually prevented any main stations on mountain-peaks. The Las Animas River was headed, and a line run down this stream connecting with Mr. Nell's trail from Fort Wingate, thence *via* the Pagosa Hot Springs, Tierra Amarilla, and the head of the east branch of the Chama, and the San Antonio River to Fort Garland.

The streams tributary to the Rio Grande from the west and its main South Fork had meanwhile been meandered by a small party. The Sangre de Christo range south of Fort Garland as far as the New Mexican line was also surveyed by Mr. Young. The interval from November 4 to November 14 was employed by Mr. Nell in measuring a base near Fort Garland and expanding it to his triangulation-stations.

A small party under the direction of Dr. Rothrock was dispatched on November 9 to Denver *via* Wet Mountain Valley, the Hardscrable Mines at Rosita, the Coal Mines at Cañon City, Colorado Springs, and mouth of Platte Cañon, to define the limits of the foot-hills and meander certain roads and streams. This party arrived at Denver December 4th, 1873. The measurement of the base and the local triangulation about Fort Garland having been completed, the escort returned to its station and the supernumerary employés were discharged. My party left Fort Garland November 14, and proceeded, *via* the Aheyta Pass, to the east of the Sangre de Cristo range, headed the Cucharas, the Apishpa, the Purgatoire, and the North Fork of the Canadian River, made a triangulation-station upon the Greenhorn Mountain; then proceeded *via* Mace's Hole, Red Creek, Cañon City, Oil Creek, the Cañon of the South Platte, North Fork of the South Platte, and Turkey Creek, to Denver, making the necessary topographical stations *en route*, and, with the lines already run by Messrs. Nell and Young, completing the survey of the foot-hills. On the 10th day of December the parties were disbanded at Denver, Colorado.

METHODS OF SURVEY.

The two peaks, Gray's and Pike's, were located from the astronomical stations at Georgetown and Colorado Springs, C. T., and the computed length and azimuth of the line connecting them were used as a base for our triangulation.

During the season thirty-six peaks, over 13,000 feet in height, were occupied, and many others of less altitude, which were fixed by triangulation processes. At the main points, the angles, repeated, were read from an instrument made by Stackpole, 8″ circle, graduated to read by vernier to 10″ of arc. At other important points a gradienta was employed. In addition to the mountain-work, nearly five thousand miles of roads and streams were meandered; the angles being read from a Casella theodolite and the distances measured by an odometer, checked by angles to fixed points, and by sextant observations made by myself for latitude. The area covered is nearly twenty-one thousand square miles.

METEOROLOGY AND HYPSOMETRY.

At all camps cistern-barometer readings were taken tri-daily when the camps were for an entire day or more, and at 7 a. m. and 9 p. m. when *en route*.

The altitudes of mountain stations were determined by cistern-barometer observations, referred either to our main camps or to the astronomical hourly stations, and by vertical angles from barometric and trigonometric bases.

At topographical stations along roads and streams aneroid readings were taken. The profiles of nineteen passes, eleven over the Atlantic and Pacific divide, and eight over subordinate ranges, were taken, and the slopes of many beds of streams near their heads determined.

GEOLOGY.

Prof. J. J. Stevenson, of New York, accompanied the party as geologist, and his report, already submitted, attests the ability and zeal with which he worked in spite of the necessarily limited facilities that could be afforded.

NATURAL HISTORY.

Dr. J. T. Rothrock and assistant John Wolfe were offered every facility and aid in my power in making collections in natural history, and the results, especially in botany, have probably never been equaled by any exploring or surveying expedition to the West. Nearly 12,000 specimens of plants from over 1,100 different species, and large collections in other branches of natural history, were gathered by these gentlemen, and are now being worked up.

To these and the other gentlemen of the party, for their efficient aid and exertions during the field-season, I desire to return my thanks.

Respectfully submitted.

W. L. MARSHALL,
First Lieutenant of Engineers.

Lieut. GEO. M. WHEELER,
Corps of Engineers, in charge.

The division moving out from Santa Fé accomplished during the season, with the assistance of the Salt Lake division, the survey of 11,000 square miles in the Territory of New Mexico, and 17,500 in Arizona, in a region possessed of remarkably interesting topographical features. The total area surveyed during the entire season was, approximately, 72,500 square miles. The degree of accuracy of the survey was considerably in advance of that of former years. The connecting station for astronomical signals of the main parties was at the Mormon observatory, Salt Lake City, until late in September, when it was transferred

to the observatory constructed under the auspices of the survey, at Ogden, Utah. Several astronomical parties were remarkably fortunate in carrying out their observations at all points selected, which were twelve in number, making it notably an astronomical campaign of a single season, marked by the most successful results. The parties are again about to take the field to continue their labors in southern and southwestern Colorado, northern and northwestern New Mexico, and northwestern Arizona. The geographical area to be occupied is represented by Atlas rectangle No. 69, southwestern quarter of No. 61, western half of No. 70, and portions of No. 68. The equipments and preparations, notwithstanding the late date of commencing the latter, are better than ever before, and the addition of a few new members to the organization has established for each of the parties an efficient *personnel*.

The number of applications by young men, graduates of the several scientific schools of the country, besides gentlemen of professional note, has been much greater than heretofore, and it is believed will increase from year to year.

The following officers and civilian assistants have been connected with the survey during the season or portions thereof: First Lieut. R. L. Hoxie, Corps of Engineers, in charge of main field party No. 2, until the close of field operations; since that time in charge of the meteorological branch of office; Lieut. Wm. L. Marshall, Corps of Engineers, in charge of main field party No. 3, and of astronomical work in the office, and since March 24 in charge of topographical branch; Lieut. S. E. Tillman, Corps of Engineers, reported for duty upon the survey on the 29th of August, and from that date until the close of field operations was in charge of main party No. 1, and of topographical branch of the office until March 24, when he was relieved and ordered for duty upon the observations for the transit of Venus; Lieut. Philip M. Price, Corps of Engineers, reported for duty on the 27th of June, 1874. Second Lieut. A. H. Russell, Third United States Cavalry, was connected with the work during the year until February 4, 1874, as acting assistant quartermaster, assistant commissary subsistence, and ordnance officer to the expedition. In addition to these duties he was in charge of a portion of main field party No. 1, during field operations, and afterward employed in the settlement of his accounts and reduction of his topographical work, until relieved. Lieut. H. R. Brinkerhoff, 15th United States Infantry, was detailed as escort officer to the expedition, in which capacity he served until July 5, 1873, when he was relieved by Second Lieut. L. H. Walker, Fifteenth United States Infantry, who in addition had charge of a small party in its operations from Fort Wingate to Fort Tulerosa, New Mexico, until close of field operations.

Acting Assistant Surgeon J. T. Rothrock, United States Army, was on duty with the survey during the entire season; Acting Assistant Surgeon H. C. Yarrow, United States Army, from January 31, 1874, and on the 3d of February was assigned to the charge of the natural-history branch of the survey, in addition to his other duties. Acting Assistant Surgeon C. G. Newberry, United States Army, reported for duty on the 7th of May, 1873, in compliance with instructions of the Surgeon General United States Army, and continued with the work until January 31, 1874, when he was relieved and his contract annulled.

Hospital Steward Theodore V. Brown has been on duty with the survey during the entire year until May 1st, when he was granted furlough for three months, with permission to go beyond the sea.

In the astronomical branch of the survey Civilian Assistants Dr. F. Kampf, William W. Marryatt, J. H. Clark, Professor S. H. Safford, and

Professor H. B. Herr have been engaged—Dr. Kampf during the entire year; Mr. Marryatt from July 1, 1873, to October 8, 1873, when his death occurred, at Bozeman, Montana; Mr. Clark from July 1 to April 1, 1874; Professor Safford for seven months; Professor Herr until August 25, 1873.

Assistants Louis Nell, Gilbert Thompson, J. J. Young, E. J. Sommer, Max E. Schmidt, R. J. Ainsworth, and, at times, Francis Klett and Edgar Schroeder have, under direction of the officers in charge, conducted field topographical work, and during the winter have been engaged in the reduction of their notes and plottings.

Assistant F. M. Lee has been employed during the entire year in the reduction of barometrical observations taken by the several parties.

In the reduction and presentation of topography Messrs. Weyss and Herman have been engaged during the whole year, and Messrs. Lang, Philp, and Aquirre a portion thereof.

In the natural-history branch Assistants H. W. Henshaw, George M. Keasby, and John Wolf were employed in making collections in the field, and Mr. Henshaw, during the winter, classified and arranged specimens collected.

Mr. T. H. O'Sullivan, photographer, secured forty-two landscape views and one hundred and four stereoscopic views, a portion of which will be published.

Mr. A. H. Wyant, artist, traveled with the photographic party, and made studies of some scenes in the Cañon de Chelle, one of which he proposes to put on canvas when his health will permit.

Assistants G. K. Gilbert, Prof. John J. Stevenson, E. E. Howell, and Oscar Loew were employed during the year in geological researches in the field, and compilation of results during the winter. Dr. Loew has made many interesting analyses regarding minerals, soils, &c. In the general duties pertaining to the work, both in the field and the office, I have been ably and faithfully assisted by Assistants W. D. Wheeler and J. B. Minick. I have again the agreeable duty of reporting the courtesies extended to the survey by the officers of the Western Union Telegraph Company, and the use of wires of that company over lines extending from Salt Lake City westward to Virginia City, Nev., eastward to Cheyenne, and thence southward to Santa Fé; and northward from Ogden, Utah, to Helena, Mont. Mr. Hibbard, the superintendent at Salt Lake City, made, with commendable zeal, all the arrangements necessary to carry out this extended programme, in which he was seconded by Mr. Woodward, manager at Denver, Colo.; as likewise the operators at Cheyenne, and at all the points from whence signals were sent and received.

The Atlantic and Pacific Telegraph Company extended also the free use of their lines. Messages for longitudinal difference were also sent over the lines of the Deseret Telegraph Company from Richfield, Utah, by Lieutenant Hoxie. Mr. Thomas Largey afforded the use of his lines from Helena to Bozeman, Mont., at reduced rates. We were thereby enabled to fix the geographical position of this important point agreeably to the wishes of Bvt. Maj. Gen. E. O. C. Ord, commanding the Department of the Platte, it being one of the extremities of the routes surveyed by Capt. William A. Jones, Corps of Engineers, from the Union Pacific Railroad to the head-waters of the Yellowstone, and beyond. Longitude connection was made between the observatory at Ogden, Utah, and that of the United States lake survey at Detroit, Mich.; Maj. C. B. Comstock, Corps of Engineers, detailing at the Detroit end of the line Assistant O. B. Wheeler for that purpose.

The officers of the United States Naval Observatory have, as heretofore, extended kind assistance to the survey.

The only casualty to be noted during the year has been the death, from fever, of Astronomical Assistant Wm. W. Maryatt, while engaged in carrying on his observations at Bozeman, Mont. This was one of the last stations to have been occupied by him during the season. He had gone forward, after having been very successful at the other stations, and was stricken down soon after reaching Bozeman, and, after a short and severe illness, died at that point. The survey lost a most valuable assistant, and the profession of astronomy an accurate, faithful, and zealous worker.

ASTRONOMICAL BRANCH.

The classes of astronomical work conducted by the survey have been of two distinct grades:

1st. Those at the main or primary station, where, by the most refined methods and use of the best class of instruments, the astronomical co-ordinates are determined with the utmost accuracy, and the meridian line of the point carefully established.

2d. At positions in the field, where, in order to carry out the scheme of survey, sextant latitude checks are required, and at other points where, the telegraph being accessible, the meridian is determined by comparing local times, the watch-errors having been obtained by sextant observations. The latter class of stations are more or less numerous, in accordance with the character of the area surveyed, and of the points within the same whose position can only well be determined by this means.

The others are at specifically-selected points near the fields of survey, and from which, measured and developed, bases controlling the triangulation can easily be laid out.

The main or primary points occupied during the season of 1873 were:

1. Georgetown, Colo.
2. Hughes, Colo.
3. Colorado Springs, Colo.
4. Labran, near Cañon City, Colo.
5. Trinidad, Colo.
6. Ogden, Utah.
7. Green River, Wyo.
8. Winnemucca, Nev.
9. Virginia City, Nev.
10. Bozeman, Mont.
11. Santa Fé, N. Mex.
12. Fort Union, N. Mex.

OBSERVATORY AT OGDEN.

A substantial observatory, of three rooms, with brick superstructure and stone foundations, has been built at this point. The walls are completed, but the dome and the middle observing-room are yet unfinished.

The co-ordinates of this position, as referred to the meridian established by the United States Coast Survey at Salt Lake City, and that of the United States Lake Survey at Detroit, Mich., have been determined. In the season of 1874 it is intended to exchange signals with the United States Naval Observatory at Washington, and resulting therefrom another check will be introduced. The several results will be discussed in the astronomical volume. The meridian of Ogden will then be assumed

as the standard of reference for the future astronomical positions determined by the survey.

There are submitted results from the reports upon the determinations of the astronomical co-ordinates of the following main or primary stations: 1. Carlin, Nev.; 2. Battle Mountain, Nev.; 3. Austin, Nev.; 4. Saint George, Utah; 5. Fort Whipple, Ariz.; 6. Fort Fred Steele, Wyo.; 7. Laramie, Wyo.; deduced from observations made during the years 1871 and 1872.

CARLIN, NEVADA.

Geographical position—longitude, 116° 7′ 20.6″, latitude, 40° 42′ 26.67″

The astronomical station is situated west-northwest from Carlin, Nev., 344 feet from the track of the Central Pacific Railroad, and 1,406 feet from the Humboldt River, which is due south, and 550 feet from the railroad-bridge over a small creek entering the Humboldt from the south. The town has nearly 2,000 inhabitants, and is mainly located from east to west along the railroad-track.

Physical geography details.—The ground around the station is level to the east and west; at a distance of 2,000 feet south and north a gentle rise commences. At a distance of two or three miles some slight hills, not more than 500 to 800 feet above the station, are visible. The elevation of the monument above the level of the sea is determined approximately to be 5,000 feet.

Meteorological conditions.—No meteorological observations of a general or special kind were made during the time of observations. As far as can be seen from the diary of the observer, there was a great diurnal change of temperature, by which the rate of the chronometer was much affected.

Description of observatory.—The observations were taken in a common wall-tent, 10 by 10 feet, with an opening for the meridian line. The telegraphic instruments were placed in the northeast corner. The wires of the Western Union Telegraph Company were used for exchange of signals. The observer had no assistance but, Carlin being the starting-point for all parties, Mr. Francis Klétt acted as recorder during the time he was present.

Description of instruments.—The astronomical instrument was a combined transit, made by Würdemann, numbered 16. It was of 26 inches focal length and 1¼ inches aperture, and mounted on four pieces of redwood scantling 4 by 4 inches, which were planted in the ground about 4 feet, and fastened together above by board cross-pieces. For telegraphing, a switch-board was used, a description of which will be found in the report on Colorado Springs, Col. The observations were taken by eye and ear, using the sideral chronometer Negus 1344; for the exchange of signals, mean solar chronometer Hutton No. 288 was always used.

Points with which connections were made were with the United States Lake-Survey Observatory at Detroit, Mich., and the United States Naval Observatory at Washington, D. C.—Detroit receiving the signals sent from Carlin and Washington. Signals were sent on May 19, 23, and 24, 1871. Carlin was occupied by E. P. Austin; the observations at Detroit were conducted by Mr. O. B. Wheeler, assistant, United States Lake-Survey; at Washington, by Prof. John R. Eastman, United States Naval Observatory. The computations relating to Carlin and also the arrangement of the report were made by Dr. F. Kampf.

Instrumental values, &c.—The value of one division of the striding-level was 1.14″; the value of one division of the zenith-level was 2.70″; of one revolution of the micrometer screw, 80.86″. The wires of the

Western Union Telegraph Company were brought into the tent by a loop. By means of automatic repeaters the signals were sent to the connected stations—the repeaters being placed at Corinne, Cheyenne, Omaha, Chicago, Pittsburgh, and Philadelphia.

In relation to the personal equation, I have to state that, as far as it is known in this office, this value for the relative error of the observers has not been determined. Mr. Austin was in Washington in the spring of 1873 for this purpose, but no satisfactory results were obtained. The resulting longitude is therefore affected by this relative error.

OBSERVATIONS TO DETERMINE THE CLOCK-CORRECTION AT THE UNITED STATES NAVAL OBSERVATORY.

The instrument used in these observations is that known as the "meridian transit," which has been employed at the Observatory for many years, and is now situated in the east wing of the building. The description of this instrument may be found in the "Washington Astronomical and Meteorological Observations" for 1862.

The transit was employed in 1871, under the direction of Prof. M. Yarnall, United States Navy, in observing stars for the "General Catalogue;" and, as the observations for time used in the longitude work were made after the regular work with the instrument was finished for the night, the same observations for collimation were employed in reducing the time-stars as were used in the reduction of the regular work.

The system of transit-threads in this instrument is composed of five groups or sets. When the clamp end of the axis is east, the set which is first reached by a star in its transit at the upper culmination is known as set A, and the others as sets B, C, D, and E.

During the early part of 1871 the equatorial interval between each thread in the five sets and the mean of B, C, and D was found to be as follows:

Thread.	Interval.	Thread.	Interval.	Thread.	Interval.	Thread.	Interval.	Thread.	Interval.
	s.		*s.*		*s.*		*s.*		*s.*
A_1......	37.897	....	....	C_1......	3.183	D_1......	15.146	E_1.....	30.003
A_2......	35.972	....	....	C_2......	1.654	D_2......	17.589	E_2.....	32.647
A_3......	34.308	B_1......	19.216	C_3......	0.014	D_3......	19.110	E_3.....	34.153
A_4......	32.745	B_2......	17.563	C_4......	1.639	....	....	E_4.....	35.820
A_5......	30.205	B_3......	15.069	C_5......	3.221	....	....	E_5.....	37.693

The reduction for C^3 is $+ 0^s.014$ when the clamp end of the axis is east. The clock used is that known as the "mural clock," and is mounted against a stone pier in the transit-room. It is connected with the chronograph in the usual way, and closes the circuit at each second, except at the sixtieth second of each minute, when a small ivory lever on the axis of the escapement-wheel raises a very delicate spring, which forms a portion of the circuit, and prevents the closing of the circuit at that instant.

The observations of all except circumpolar stars were recorded in the usual manner by the chronograph, which is described in the annual volume for 1862.

In the reductions, whenever a broken set of observations occurred, each thread was reduced separately.

Instrumental corrections.—The corrections to the observed transit of a star were derived from the observed and computed errors c', n', and m'.

The error of collimation is represented by c'; the equatorial value of

the distance between the line of collimation and the true meridian at the pole, by n'; and the distance between the line of collimation and the true meridian at the equator, by m':

The quantities represented by n' and m' are used instead of errors of azimuth and level.

By means of a collimating eye-piece, the error of collimation and level was determined by reversing the instrument over a basin of mercury, and measuring with the right-ascension micrometer the distance between the central thread (c_3) and its image reflected from the mercury.

Denoting by—

c, n, and m the corrections obtained from the observed and computed errors c', n', and m';

$2\,\Delta$, the distance of the central thread *west* of its image when the clamp-end of the axis is east;

$2\,\Delta'$, the distance of the central thread west of its image when the clamp end of the axis is *west*;

p, the correction for the excess of the radius of the clamp-pivot$=0^s.008$;

r, the equatorial distance of the middle thread from the mean of sets B, C, and D$=0^s.014$;

a, the correction for diurnal aberration$=0^s.016$;

b, the level-correction;

α, the adopted place of the star;

α', the observed place of the star;

δ, the declination of the star;

φ, the latitude of the observing-station;

C', the approximate clock-correction; and

C, the clock-correction derived from the observation of each star—

and we have the following formulas, which have been employed in reducing the observations for time:

n was determined from the observations of circumpolar stars.

The quantities Δ and Δ' are given in revolutions of the micrometer-head, each revolution $=1^s.5865$.

$$c=\tfrac{1}{2}(\Delta-\Delta')-p-r-a \text{ for clamp east.}$$
$$c=-\tfrac{1}{2}(\Delta-\Delta')+p+r-a \text{ for clamp west.}$$
$$b=-\tfrac{1}{2}(\Delta+\Delta')-p \text{ for clamp east.}$$
$$b=-\tfrac{1}{2}(\Delta+\Delta')+p \text{ for clamp west.}$$
$$n=\frac{\alpha-(\alpha'+C'+c\sec\delta)}{\sec\delta}$$
$$m=-n\tan\varphi+b\sec\varphi$$
$$C=\alpha-(\alpha'+m+n\tan\delta+c\sec\delta)$$

In the column "Adopted right ascension" in the following table, the places of the clock-stars are those used at the observatory in 1871, some of the Nautical-Almanac places being slightly changed.

Observed clock-corrections, United States Naval Observatory.

Date.	Number.	Object.	Seconds of transit over wires. I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	Mean.		Instrumental corrections.	Obsèrved place.	Adopted right ascension.			Clock-correction.
			s.	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*m.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*s.*
1871. May 19	1	ε Bootis	1.5	3.3	6.1	19.6	21.4	23.2	25.0	26.8	40.4	43.1	44.8	39	23.20	+ 0.08	23.28	14	39	22.64	−0.64
	2	β Bootis	......	......	......	3.3	5.3	7.4	9.5	11.6	......	......	......	57	7.42	+ 0.15	7.57	14	57	6.94	−0.63
	3	β Libræ	46.6	48.2	50.8	3.1	4.6	6.2	7.8	9.6	21.6	24.0	25.5	10	6.17	− 0.07	6.10	15	10	5.42	−0.68
	4	μ^1 Bootis	15.0	17.0	19.9	35.4	37.2	39.1	41.3	43.2	58.4	1.6	3.6	19	39.25	+ 0.13	39.38	15	19	38.76	−0.62
	5	α Coronæ Borealis	......	......	......	32.8	35.5	37.0	49.5	52.4	54.0	56.0	58.1	29	15.70	+ 0.06	15.76	15	29	15.11	−0.65
	6	α Serpentis	37.7	39.3	41.8	53.8	55.3	56.9	58.6	0.2	12.2	14.6	16.2	37	56.96	− 0.02	56.94	15	37	56.29	−0.65
	7	ε Serpentis	......	......	......	21.9	23.5	25.2	26.9	28.5	......	......	......	44	25.20	− 0.03	25.17	15	44	24.60	−0.57
	8	δ Aquilæ	42.4	43.8	46.2	58.5	59.9	1.5	3.0	4.4	16.6	18.8	20.5	19	1.42	− 0.03	1.39	19	19	0.57	−0.82
	9	κ Aquilæ	39.3	40.9	43.8	55.4	57.2	58.8	0.5	2.2	13.9	16.5	18.2	29	58.79	− 0.06	58.73	19	29	57.93	−0.80
	10	γ Aquilæ	49.6	51.5	53.8	6.0	7.5	9.1	11.1	12.8	24.6	27.3	28.5	40	9.25	− 0.01	9.24	19	40	8.46	−0.78
	11	α Aquilæ	11.6	13.1	15.9	27.7	29.3	30.9	32.5	34.1	46.4	48.9	50.5	44	30.99	− 0.01	30.98	19	44	30.19	−0.79
	12	β Aquilæ	41.0	42.6	45.0	57.0	58.5	0.1	1.8	3.2	15.4	17.8	19.4	49	0.16	− 0.02	0.14	19	48	59.39	−0.75
	13	λ Ursæ Minoris	......	......	......	54.5	17.0	40.0	7.0	31.0	......	......	......	53	42.16	+14.87	57.03	19	53	56.20	......
May 23	14	η Herculis	......	......	......	......	......	......	6.3	9.7	11.9	14.0	16.5	38	27.51	− 0.13	27.38	16	38	30.23	+2.85
	15	κ Ophiuchi	13.2	14.6	17.6	29.5	31.1	32.6	34.2	35.8	48.0	50.4	52.1	51	32.59	− 0.16	32.43	16	51	35.20	+2.77
	16	d Herculis	......	28.3	31.3	45.6	47.6	49.5	51.5	53.4	7.8	10.8	......	56	49.55	− 0.13	49.42	16	56	52.28	+2.86
	17	a^1 Herculis	25.1	26.5	......	41.3	43.0	44.8	46.5	48.0	0.3	2.8	......	8	44.74	− 0.15	44.59	17	8	47.40	+2.81
	18	δ Ursæ Minoris	51.0	16.5	58.0	20.5	45.0	14.0	44.0	6.5	29.5	11.0	40.0	14	14.18	− 0.77	13.41	18	14	16.13	......
	19	δ Aquilæ	......	......	......	13.2	15.7	17.3	28.5	31.0	32.5	......	36.1	18	58.17	− 0.16	58.01	19	19	0.68	+2.67
	20	γ Aquilæ	46.6	48.1	50.5	2.7	4.5	6.1	7.7	9.2	21.5	23.8	25.6	40	6.03	− 0.15	5.88	19	40	8.57	+2.69
	21	α Aquilæ	8.4	9.8	12.2	24.5	26.1	27.7	29.4	31.0	43.0	45.7	47.1	44	27.72	− 0.16	27.56	19	44	30.30	+2.74
	22	β Aquilæ	37.8	39.3	41.7	53.9	55.4	57.0	58.6	0.2	12.2	14.6	16.3	48	57.00	− 0.16	56.84	19	48	59.50	+2.66
	23	τ Aquilæ	29.3	30.8	33.2	45.4	46.9	48.5	50.1	51.7	3.6	......	7.8	57	48.51	− 0.16	48.35	19	57	51.13	+2.78
May 24	24	α Serpentis	35.1	36.4	39.0	51.1	52.5	54.1	55.8	57.2	9.5	12.1	13.9	37	54.25	− 0.11	54.14	15	37	56.33	+2.19
	25	ε Serpentis	3.4	4.9	7.4	19.5	21.0	22.7	24.2	25.7	37.8	40.3	42.1	44	22.64	− 0.11	22.53	15	44	24.66	+2.13
	26	ε Coronæ Borealis	52.9	54.6	57.2	10.9	12.5	14.4	16.2	18.1	31.5	34.3	36.2	52	14.44	− 0.09	14.35	15	52	16.43	+2.08
	27	δ Ophiuchi	15.5	17.1	19.7	31.5	33.1	34.7	36.2	37.8	49.8	52.2	54.0	7	34.69	− 0.13	34.56	16	7	36.67	+2.11
	28	δ Ursæ Minoris	......	......	......	21.0	48.5	14.5	40.0	9.0	......	......	......	14	14.66	− 0.51	14.15	18	14	16.26	......
	29	α Lyræ	9.3	11.1	14.2	29.6	31.5	33.6	35.8	37.7	53.1	56.1	58.3	32	33.66	− 0.08	33.58	18	32	35.79	+2.21
	30	β Lyræ	55.4	57.3	0.3	14.5	16.3	18.4	20.3	22.3	36.4	39.4	41.5	45	18.37	− 0.09	18.28	18	45	20.43	+2.15
June 16	31	a^1 Herculis	29.7	31.4	34.1	46.3	47.9	49.7	51.4	52.9	5.3	7.8	9.6	8	49.64	− 0.22	49.86	17	8	47.65	+2.21
	32	α Ophiuchi	40.6	42.7	45.2	57.3	58.9	0.5	2.3	4.0	16.0	18.6	20.2	29	0.57	− 0.21	0.78	17	28	58.52	−2.26
	33	μ Herculis	......	......	......	25.0	26.5	28.2	30.1	32.0	45.5	48.2	50.0	41	28.35	− 0.30	28.65	17	41	26.42	−2.23
	34	δ Ursæ Minoris	......	......	......	21.5	48.0	15.0	41.5	9.0	......	......	......	14	15.00	− 4.92	19.92	18	14	17.67	......
	35	1 Aquilæ	......	......	......	11.8	13.3	15.1	16.7	18.4	30.2	32.9	34.3	28	15.04	− 0.12	15.16	18	28	12.95	−2.21
	36	α Lyræ	13.5	15.5	18.9	34.2	36.1	38.0	40.1	42.1	57.3	0.7	2.7	32	38.10	− 0.36	38.46	18	32	36.20	−2.26
	37	β Lyræ	59.7	2.0	4.9	19.1	20.9	22.9	24.9	26.6	41.0	43.9	45.6	45	22.86	− 0.33	23.19	18	45	20.87	−2.32
	38	ζ Cygni	7.9	9.8	12.7	26.6	28.2	30.1	32.2	33.8	47.5	50.2	52.0	7	30.09	− 0.31	30.40	21	7	28.08	−2.32
	39	1 Pegasi	50.0	51.8	54.4	7.1	8.7	10.5	12.2	14.0	26.6	29.2	31.1	16	10.51	− 0.24	10.75	21	16	8.45	−2.30

Observed clock-corrections, United States Naval Observatory—Continued.

Date.	Number.	Object.	Seconds of transit over wires.											Mean.	Instrumental corrections.	Observed place.	Adopted right ascension.	Clock-corrections.
			I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.					
1871.			*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*m.* *s.*	*s.*	*s.*	*h.* *m.* *s.*	*s.*
June 16	40	β Aquarii	29.9	31.5	34.0	46.0	47.6	49.2	50.9	52.5	4.5	7.1	8.5	24 49.25	−0.13	49.38	21 24 47.15	−2.23
	41	ξ Aquarii	36.9	38.5	40.9	53.3	54.7	56.2	57.8	59.5	......	......	......	30 56.27	−0.12	56.39	21 30 54.09	−2.30
	42	ε Pegasi	34.8	36.5	38.9	51.0	52.6	54.2	55.8	57.4	9.5	11.8	13.5	37 54.17	−0.20	54.37	21 37 52.09	−2.28

Nos. 2, 7, 13, and 28, set C.
14, set E.
16, B_1 and D_3 rejected.
17, B_3 and D_3 rejected.
19, sets D and E; E_4 rejected.
23, D_2 rejected.
33, sets C and D.
34, set C; cloudy.
35, sets C and D.
41, sets B. and C.

COLLIMATION.

May 19. 9. Image east $0^r.16$; clamp east.
Image west $0^r.19$; clamp west.
May 23. 9. Image west $0^r.17$; clamp west.
May 24. 9. Image west $0^r.19$; clamp west.
Image east $0^r.10$; clamp east.
June 16. 9. Image west $0^r.20$; clamp east.
Image west $0^r.42$; clamp west.
On the 23d and 24th the stars were very unsteady.

While observing on May 19 and June 16, the clamp was east, and west on the 23d and 24th of May.

The values of m, n, and c, used in the reduction, are as follows:

Date.	m	n	c
	s.	s.	s.
May 19	−0.143	+0.184	+0.102
May 23	−0.046	+0.088	−0.114
May 24	−0.010	+0.082	−0.110
June 16	−0.113	+0.242	+0.050

From the clock-corrections obtained from the observations the following corrections and rates were computed by the method of least squares, and have been employed to determine the error of the clock at the time of the interchange of signals on each night:

Date.	Sidereal hour.	Correction.	Hourly rate.
		s. s.	s.
May 19	14.0	−0.594±0.007	−0.034
May 23	16.0	+2.854±0.010	−0.039
May 24	15.0	+2.117±0.012	+0.016
June 16	17.0	−2.234±0.007	−0.012

UNITED STATES LAKE-SURVEY, DETROIT, MICHIGAN.

The dates of the observations are May 19, 23, and 24, and June 1, 3, 10, 16, 26, and 29, 1871. The observer at Detroit was Mr. O. B. Wheeler, assistant United States lake-survey, and the instruments used were the Troughton and Simms transit of 43 inches focal length, clock No. 184, Bond & Son, and chronograph No. 216, Bond & Son.

The stone pier upon which the transit-instrument was mounted is situated 321.0 feet west and 294.0 feet north of the southwest corner of the stone foundation of the Westminster church, on Washington avenue.

The reductions have been made by Messrs. Thomas Russel, C. F. Burton, and John Eisenmann, subassistants United States lake-survey. A preliminary reduction by high and low stars of May 19, 23, and 24, was made by Mr. Burton. Two reductions by the method of least squares, on different suppositions, were made, either of which would cause an extreme range of only $0^s.05$ from the preliminary reduction.

For the remaining dates, the high and low star reductions were made by Mr. Eisenmann, and the least-square reductions by Mr. Russel. The agreement in extreme cases was the same as above.

In the following tables are contained the abbreviations:

$C\Delta i$ = reduction to the middle wire;

Aberr = diurnal aberation;

$B\,b$ = level-correction;

$C\,c$ = collimation-correction;

t' = observed time of transit of a star, commonly the mean of five wires;

$t = t'$ the above corrections being made;

α = right ascension of a star;

$(\alpha - t)$ — (an assumed Δt) = the absolute termof the equations of condition;

a = deviation from the meridian, + when the instrument points east of south;

c = distance of the middle wire from the line of collimation;

ρ = hourly rate of the clock;

Δt = clock-correction, — when fast; + when slow.

NOTES.—On May 19, 23, and 24, $t = t'$, as above, except that the the collimation-correction is not included. On June 16, a = the deviation to be applied before the exchange of signals, and a' = that to be applied after the exchange of signals.

When $C\Delta i$ is omitted, t' = the mean of the several wires reduced to the middle wire.

Computation of clock-correction for Detroit, May 19, 1871.

Ill.	Star.	C Δ *i*	Aberr.	B *b*	*t'*	*a*	(*a*−*t*)	*v*
		s.	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*s.*	*s.*
E.	Polaris, L. C	....	+.58	+2.01	13 11 24.75	13 10 59.40	−27.94	....
W.	Polaris, L. C	....	+.58	−2.23	11 29.60	....	28.55	....
	ζ Virginis	+.03	−.01	+ .06	28 39.41	28 08.37	31.12	+.02
	η Ursæ Majoris	+.05	−.02	+ .15	42 59.87	42 29.05	31.00	−.22
	η Bootis	+.03	−.02	+ .13	49 04.80	48 33.80	31.14	−.03
	τ Virginis	+.03	−.01	+ .12	55 37.29	55 06.13	31.30	+.13
	ρ Bootis	+.04	−.02	+ .25	14 26 48.85	14 26 17.67	31.45	+.17
W.	ε Bootis	+.03	−.02	+ .20	39 53.85	39 22.66	31.40	+.09
E.	β Bootis	−.04	−.02	+ .09	57 38.34	57 06.91	31.46	+.06
	β Libræ	−.03	−.01	+ .05	15 10 36.60	15 10 05.42	31.19	−.17
	μ^1 Bootis	−.04	−.02	+ .09	20 10.24	19 38.76	31.51	+.07
	α Serpentis	−.03	−.02	+ .07	38 27.62	37 56.27	31.34	−.08
	ε Serpentis	−.03	−.01	+ .07	44 55.94	44 24.62	31.35	−.12
	δ Ophiuchi	−.03	−.01	+ .07	16 08 07.94	16 07 36.60	31.37	−.15
	ζ Ophiuchi	−.03	−.01	+ .14	19 00 01.73	18 59 29.82	32.01	+.16
	ω Aquilæ	−.03	−.01	+ .11	12 18.40	11 46.62	31.85	−.13
	γ Aquilæ	−.03	−.01	+ .16	40 40.43	40 08.43	32.12	+.07
	α Aquilæ	−.03	−.01	+ .15	45 02.14	44 30.15	32.10	+.03
E.	β Aquilæ	−.03	−.01	+ .15	49 31.56	48 59.36	32.31	+.23

Normal equations.

$$+1965.223\,a + 3.671\,c + 167.496\,\rho + 70.250\,\delta\theta - 168.098 = 0$$
$$+3.671\,a + 3458.724\,c - 36.620\,\rho + 4.820\,\delta\theta + 31.768 = 0$$
$$7.496\,a - 36.620\,c + 104.196\,\rho + 2.170\,\delta\theta - 30.069 = 0$$
$$0.250\,a + 4.820\,c + 2.170\,\rho + 19.000\,\delta\theta + 3.510 = 0$$

$a = +0^s.09$

$c = -0^s.007$, lamp east.

$\rho = +0^s.1493$, rate per hour.

$\Delta t = -31^s.54. \pm 0^s.023$, at $15^h\ 57^m$.

Computation of clock-correction for Detroit, May 23, 1871.

Ill.	Star.	C Δ *i*	Aberr.	B *b*	*t'*	*a*	(*a*−*t*)	
		s.	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*s.*	*s.*
E.	Polaris, L. C	....	+.58	−1.56	13 11 55.87	13 11 02.14	−52.75	....
W.	Polaris, L. C	....	+.58	−3.78	11 59.76	....	54.42	....
	ζ Virginis	+.03	−.01	+ .12	28 50.01	28 08.36	41.79	−.15
	η Ursæ Majoris	+.05	−.02	+ .30	43 10.32	42 29.00	41.65	+.03
	η Bootis	+.03	−.01	+ .19	49 15.43	48 33.79	41.85	−.04
	τ Virginis	+.03	−.01	+ .17	55 47.91	55 06.13	41.97	−.02
W.	α Bootis	+.03	−.01	+ .26	14 10 29.69	14 09 47.92	42.05	+.10
E.	5 Ursæ Minoris	−.13	−.06	+ .52	28 35.24	27 54.47	41.10	....
	α^2 Libræ	−.03	−.01	+ .08	44 28.17	43 46.09	42.12	−.12
	ψ Bootis	−.04	−.02	+ .16	59 38.71	58 56.60	42.21	+.16
	β Libræ	−.03	−.01	+ .08	15 10 47.54	15 10 05.45	42.13	−.14
	μ^1 Bootis	−.04	−.02	+ .14	20 20.95	19 38.77	42.26	+.22
	α Coronæ Borealis	−.04	−.02	+ .11	29 57.40	29 15.13	42.32	+.19
	α Serpentis	−.03	−.01	+ .07	38 38.46	37 56.30	42.19	−.07
	ε Serpentis	−.03	−.01	+ .07	45 06.77	44 24.65	42.15	−.14
	ε Coronæ Borealis	−.04	−.02	+ .10	52 58.65	52 16.49	42.20	+.02
	d Sagittarii	−.03	−.02	+ .11	19 10 49.10	19 10 06.29	42.87	−.03
	ω Aquilæ	−.03	−.01	+ .18	12 29.52	11 46.73	42.93	+.17
E.	δ Aquilæ	−.03	−.01	+ .16	19 43.29	19 00.63	42.78	−.04
W.	κ Aquilæ	+.03	−.01	+ .13	30 40.48	29 58.00	42.63	−.24
	γ Aquilæ	+.03	−.01	+ .17	40 51.03	40 08.54	42.68	−.12
	α Aquilæ	+.03	−.01	+ .19	45 12.87	44 30.26	42.82	.00
W.	β Aquilæ	+.03	−.01	+ .20	49 42.12	48 59.47	−42.87	+.03

Normal equations.

$$
\begin{aligned}
+ 1972.912\,a &- 8.095\,c + 168.577\,\rho + 70.62\,\delta\theta + 802.347 = 0\\
- 8.095\,a &+ 3477.516\,c - 3.731\,\rho + 6.26\,\delta\theta + 73.934 = 0\\
+ 168.577\,a &- 3.731\,c + 131.784\,\rho + 44.713 = 0\\
+ 70.620\,a &+ 6.260\,c + 23.00\,\delta\theta + 51.740 = 0
\end{aligned}
$$

$a = -0^s.38.$

$c = -0^s.02$, lamp east.

$\rho = +0^s.147$, rate per hour.

$\Delta t = -42^s.08. \pm 0^s.019$, at $16^h\,04^m$

Computation of clock-correction for Detroit, May 24, 1871.

Ill.	Star.	C Δ i	Aberr.	B b	t′	a	(a−t)	v
		s.	s.	s.	h. m. s.	h. m. s.	s.	s.
W.	Polaris, L. C	....	+.58	−3.78	13 12 01.85	13 11 02.74	−55.91	......
E.	Polaris, L. C	....	+.58	−2.23	11 54.94	....	50.55	......
	ζ Virginis	−.03	−.01	+ .09	28 53.43	28 08.35	45.13	−.16
	η Bootis	−.03	−.02	+ .12	49 18.88	48 33.78	45.17	−.09
	α Bootis	−.03	−.02	+ .12	14 10 33.12	14 09 47.92	45.27	−.02
	ρ Bootis	−.04	−.02	+ .14	27 03.00	26 17.66	45.42	+.15
	ε Bootis	−.04	−.02	+ .14	40 07.97	39 22.66	45.39	+.08
E.	α^2 Libræ	−.03	−.01	+ .07	44 31.33	43 46.09	45.27	−.20
W.	β Bootis	+.04	−.02	+ .22	57 51.88	57 06.90	45.22	+.11
	β Libræ	+.03	−.01	+ .13	15 10 50.52	15 10 05.45	45.22	−.13
	μ^1 Bootis	+.04	−.02	+ .31	20 23.66	19 38.78	45.21	+.04
	α Coronæ Borealis	+.04	−.02	+ .31	30 00.16	29 15.14	45.35	+.10
	α Serpentis	+.03	−.01	+ .23	38 41.54	37 56.31	45.48	+.14
	ε Coronæ Borealis	+.04	−.02	+ .31	53 01.54	52 16.49	45.38	+.09
	β Scorpii	+.03	−.02	+ .14	58 43.04	57 57.84	45.35	−.12
	δ Ophiuchi	+.03	−.01	+ .20	16 08 21.86	16 07 36.65	45.43	+.01
	d Sagittarii	+.03	−.02	+ .07	19 10 51.83	19 10 06.32	45.59	−.18
W.	ω Aquilæ	+.03	−.01	+ .10	12 32.20	11 46.75	45.57	−.11
E.	γ Aquilæ	−.03	−.01	+ .08	40 54.43	40 08.57	45.90	+.04
	α Aquilæ	−.03	−.01	+ .08	45 16.21	44 30.29	45.96	+.08
E.	β Aquilæ	−.03	−.01	+ .07	49 45.57	48 59.50	−46.10	+.20

Normal equations.

$$
\begin{aligned}
+ 1967.037\,a &- .0675\,c + 163.305\,\rho + 72.460\,\delta\theta + 519.956 = 0\\
- 0.675\,a &+ 3458.511\,c + 11.019\,\rho - 1.480\,\delta\theta + 222.909 = 0\\
+ 163.305\,a &+ 11.019\,c + 101.074\,\rho + 32.893 = 0\\
+ 72.460\,a &- 1.480\,c + 21.000\,\delta\theta + 24.870 = 0
\end{aligned}
$$

$a = -\ 0^s.26$

$c = -\ 0^s.07$, lamp east.

$\rho = +\ 0^s.098$, rate per hour.

$\Delta t = -\ 45^s.28 \pm 0^s.020$, at $15^h\,54^m$

Carlin, Nevada, May 19, 1871.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
o Virginis	E.	11 53 46.09	+0.06	+ 9.70	−0.23	11 53 55.62	11 58 38.97	+4 43.35
ε Corvi	E.	58 29.58	+0.02	+ 17.65	−0 25	58 47.00	12 3 30.55	43.55
4 Draconis	E.	12 2 24.58	+0.12	− 55.78	−1.14	12 1 27.78	6 10.99	43.21
13 Comæ	E.	13 3.16	0.00	+ 4.95	−0.26	13 7.85	17 50.99	43.14
δ Corvi	E.	18 13.30	−0.04	+ 15.99	−0.24	18 29.01	23 12.86	43.85
β Corvi	E.	22 36.70	−0.07	+ 17.87	−0.25	22 54.25	27 37.80	43.55
21 Cassiopeæ, L. C.	W.	31 24.60	−0.20	+ 61.85	−0.85	32 25.20	37 7.33	42.13
32 Camelopardalis	W.	45 37.38	+0.56	−122.48	+2.22	43 37.68	48 20.57	42.89
θ Virginis	W.	58 20.47	+0.02	+ 13.21	+0.23	58 33.93	13 3 17.38	43.45
α Virginis	W.	13 13 26.94	+0.04	+ 14.61	+0.23	13 13 41.82	18 25.07	43.25
Virginis	W.	23 12.64	+0.07	+ 12.01	+0.23	23 24.95	28 8.37	+4 43.42
Mean correction for $12^h\,40^m$ local sidereal time								+4 43.254
Excluding polar stars								+4 43.445

Normal equations.

$$
\begin{aligned}
0 &= -\ 2.51 + 11.00\,\delta T - 0.57\,a' + 1.28\,c & \delta T &= +\,0^s.254\\
0 &= +\,18.44 - 0.57\,\delta T + 68.94\,a' + 62.19\,c & a' &= -\,0^s.058\\
0 &= +\,35.55 + 1.28\,\delta T + 62.19\,a' + 140.36\,c & c &= -\,0^s.230
\end{aligned}
$$

(To avoid large numbers, an azimuth of $+18^s.50$ was introduced: a', found by the method of least squares, gives the correction of the adopted azimuth; therefore, $a = +18^s.442$.)

Carlin, Nevada, May 23, 1871.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
ζ Ophiuchi	E.	16 25 20.82	−0.02	+ 4.46	−0.01	16 25 25.25	16 30 4.89	+4 39.64
η Herculis........	W.	33 49.96	−0.22	+ 0.20	+0.02	33 49.96	38 30.22	40.26
ι Ophiuchi	W.	43 12.84	−0.17	+ 2.90	+0.01	43 15.58	47 55.84	40.26
κ Ophiuchi	W.	46 52.46	−0.18	+ 2.96	+0.01	46 55.25	51 35.16	39.91
ε Ursæ Minoris ...	W.	55 14.38	−0.72	−27.78	+0.08	54 45.96	59 25.94	39.98
α Herculis........	W.	17 4 4.77	−0.15	+ 2.58	+0.01	17 4 7.21	17 8 47.38	40.17
ω Draconis	E.	33 13.82	−0.63	− 7.35	−0.03	33 5.81	37 46.01	+4 40.20
Mean correction for 17^h 0^m local sidereal time..........								+4 40.060

Normal equations.

$$0 = -\ 1.90 + 7.00\,\delta T - \ 3.90\,a - \ 7.97\,c \qquad \delta T = +\,0^s.060$$
$$0 = +\,10.25 - 3.90\,\delta T + 27.26\,a' + 32.16\,c \qquad a' = -\,0.353$$
$$0 = +\,12.66 - 7.97\,\delta T + 32.16\,a' + 68.53\,c \qquad c = -\,0.012$$

I introduced a preliminary azimuth of + 6s.00; the azimuth of the instrument was + 5s.647. The observations of η Draconis and ω Draconis differ so much that they had to be excluded.

Carlin, Nevada, May 24. 1871.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
γ Cephei, L. C	E.	11 29 21.72	+1.22	−4.18	+1.32	11 29 20.08	11 34 2.59	+4 42.51
β Leonis	E.	37 49.86	−0.55	−0.48	−0.31	37 48.52	43 29.27	40.75
γ Ursæ Majoris ..	E.	42 23.65	−0.97	+0.44	−0.52	42 22.60	47 3.00	40.40
ο Virginis	E.	53 59.94	−0.48	−0.57	−0.30	53 58.59	58 38.92	40.33
4 Draconis	E.	12 1 30.32	−1.84	+3.23	−1.48	12 1 30.23	12 6 10.58	40.35
β Corvi	E.	22 58.86	−0.24	−1.04	−0.32	22 57.26	27 37.76	40.50
21 Cassiopeæ, L. C.	W.	32 31.19	+0.34	−3.57	−1.11	32 26.85	37 6.05	39.20
32 Camelopardalis	W.	43 30.87	−2.68	+7.10	+2.90	43 38.19	48 19.81	41.62
θ Virginis	W.	58 37.92	−0.24	−0.77	+0.30	58 37.21	13 3 17.36	40.15
α Virginis	W.	13 13 45.64	−0.15	−0.85	+0.31	13 13 44.95	18 25.05	+4 40.10
Mean correction of chronometer excluding the polar stars, for 13^h 0^m local sidereal time.								+4 40.372

Normal equations.

$$0 = +\ \ 4.22 + 10.00\,\delta t + \ 0.63\,a$$
$$0 = -\,89.14 + \ 0.63\,\delta t + 82.97\,a \qquad a = -\,1^s.072$$

Several other computations have been made, giving for the correction of chronometer no better result. The error of collimation was adopted to − 0s.30.

Carlin, Nevada, May 24, 1871.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m.*
ε Serpentis	W.	15 40 45.54	−0.06	−1.25	+0.30	15 40 44.53	15 44 24.65	+4 40.12
ζ Ursæ Minoris ..	W.	44 1.61	−0.19	+6.32	+1.47	44 9.21	48 49.34	40.13
β^1 Scorpii..........	W.	53 19.06	−0.01	−1.95	+0.32	53 17.42	57 57.84	40.42
δ Ophiuchi	W.	16 2 57.60	0.00	−1.48	+0.30	16 2 56.42	16 7 36.65	40.23
τ Herculis	E.	11 14.00	−0.17	+0.32	−0.44	11 13.71	15 53.70	39.99
η Draconis........	E.	17 36.72	−0.24	+1.61	−0.64	17 37.45	22 17.79	40.34
ζ Ophiuchi........	E.	25 26.92	−0.07	−1.67	−0.30	25 24.88	30 4.89	40.01
η Herculis	E.	33 51.10	−0.13	−0.07	−0.39	33 50.51	38 30.22	+4 39.71
Mean correction for 16^h 10^m..........								+4 40.12

Normal equations.

$$0 = -\ \ 2.78 + 8.00\,\delta t - \ 0.86\,a \qquad \delta t = +\,0^s.120$$
$$0 = +\,24.99 - 0.86\,\delta t + 11.74\,a \qquad a = -\,2^s.120$$

The error of collimation of the instrument is adopted as −0s.30.

The following table contains the corrections of the chronometer and its rate, to obtain the correction for the time of exchange:

Date.	Local sidereal time.	Corrections of chronometer.	Hourly rate.
	h.	*m.* *s.*	*s.*
May 19, 1871	12.667	+ 4 43.445	− 0.034
May 23, 1871	17.000	+ 4 40.060	+ 0.009
May 24, 1871	14.508	+ 4 40.246	+ 0.009

For exchange, mean-solar-time chronometer Hutton No. 288 was always used. May 19, I find in the proper place only one comparison of Negus 1344 with Hutton 288:

	h.	*m.*	*s.*	*h.*	*m.*	*s.*
Negus...1344	13	30	20.0	13	33	27.0
Hutton.. 288	9	21	20.0	9	24	26.5

Hutton 288, at $9^h\ 22^m\ 53^s.25$, is slow of local sidereal time $4^h\ 13^m\ 43^s.666$. In another place I find one comparison made May 19, in the morning, and one at nearly the same time May 20:

	May 19.			*May* 20.					
	h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
Negus...	0	32	12.0	1	41	31.0	1	44	34.0
Hutton..	20	25	21.50	21	30	29.5	21	33	32.0

Therefore, I find the rate of Hutton 288 from the morning to the evening of May 19, $+\ 9^s.9785$, and from the evening to the next morning, $+\ 9^s.9641$, both for one hour of Hutton 288. To reduce Hutton for the time of exchange, the mean $+\ 9^s.9713$ is used.

For May 23 and May 24, one comparison was made before and after exchange.

May 23.

	h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
Negus...1344	13	27	18.0	13	30	25.0	13	33	34.0
Hutton.. 288	9	2	24.5	9	5	31.0	9	8	39.5

And after exchange:

	h.	*m.*	*s.*	*h.*	*m.*	*s.*
Negus...1344	16	12	10.0	16	15	15.0
Hutton.. 288	11	46	49.5	11	49	54.0

May 24.

	h.	*m.*	*s.*	*h.*	*m.*	*s.*
Negus...1344	13	34	32.0	13	37	35.0
Hutton.. 280	9	5	37.5	9	8	40.0

After exchange:

	h.	*m.*	*s.*	*h.*	*m.*	*s.*
Negus...1344	15	30	19.0	15	33	20.0
Hutton.. 288	11	1	5.5	11	4	6.0

From these comparisons and the rate given for Negus 1344, the following table for Hutton 288 is derived:

Date.	Hours on the face of Hutton's chronometer.	Hutton 288 behind local sidereal time.	Losing per hour on face of Hutton's chronometer.	Logarithm.
	h. *m.* *s.*	*h.* *m.* *s.*	*s.*	
May 19, 1871	9 22 53.25	4 13 43.666	9.9713	0.9987518
May 23, 1871	10 26 56.72	4 29 47.454	9.8478	0.9933402
May 24, 1871	10 4 52.25	4 33 44.496	9.8832	0.9948986

The logarithm is used to convert the chronometer-time of the means of the signals into sidereal time.

EXCHANGE OF SIGNALS.

Signals sent from the Washington Observatory.

On the 19th of May the first signals to Carlin were at intervals of one second, and were sent by so arranging the apparatus that the clock *broke* a *closed* circuit at each second. These signals could not be used at Carlin.

Afterward an attempt was made to send signals by causing the clock to *close* an *open* circuit, but these signals failed to get through.

So much objection was made at Carlin to the clock-signals that signals were sent, finally, at intervals of ten seconds, with an ordinary message-key, by breaking the circuit in coincidence with the beat of the clock as indicated by the sounder in the local circuit.

Similar signals were sent on the 23d and 24th of May.

On the 16th of June signals were sent, at intervals of ten seconds, directly from the clock, by switching the clock into the main line at the proper time to enable it to break the circuit at the desired second.

Signals sent to the Observatory.

Signals from Carlin and Austin were received on the Observatory chronograph.

Exchange of signals between Washington, D. C., Detroit, Mich., and Carlin, Nev.

MAY 19, 1871.—*Signals sent from Washington.*

Washington clock.	Detroit clock.	Carlin chronometer.	Washington clock.	Detroit clock.	Carlin chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
17 35 0.00	17 11 30.75	10 44 45.20	17 37 30.00	17 14 0.90	10 47 15.00
10.00	40.70	55.40	40.00	10.82	24.80
20.00	50.77	45 5.30	50.00	20.85	34.90
			38 0.00	30.80	45.00
36 0.00	12 30.77	45 45.60	10.00	40.82	55.00
10.00	40.83	55.10	20.00	50.81	48 4.80
20.00	50.86	46 5.60	30.00	15 0.82	14.90
30.00	13 0.89	15.20			
40.00	10.91	25.10	Mean, 17 36 52.94	17 13 23.78	10 46 38.06
50.00	20.90	35.20			
37 0.00	30.86	44.90			

MAY 23, 1871.—*Signals sent from Washington.*

Washington clock.	Detroit clock.	Carlin chronometer.	Washington clock.	Detroit clock.	Carlin chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
18 35 0.00	18 11 45.19	11 28 48.30	18 37 50.00	18 14 35.11	11 31 37.90
10.00	55.28	58.60	38 0.00	45.05	47.90
20.00	12 5.23	29 8.50			
30.00	15.27	18.50	39 0.00	15 45.18	32 47.70
40.00	25.20	28.40	10.00	55.18	57.60
50.00	35.19	38.40	20.00	16 5.00	33 7.60
36 0.00	44.99	48.10	30.00	15.00	17.60
			40.00	25.00	27.60
37 0.00	13 45.05	30 48.10	50.00	35.00	37.60
10.00	55.80	58.60	40 0.00	45.20	47.60
20.00	14 5.16	31 8.00			
30.00	15.11	17.90	Mean, 18 37 30.00	18 14 15.15	11 31 18.02
40.00	25.05	28.00			

MAY 23, 1871.—*Signals sent from Carlin.*

FIRST SERIES.

Washington clock. h.	m.	s.	Detroit clock. h.	m.	s.	Carlin chronometer. h.	m.	s.
17	53	.....	17	29	.....	10	47	.....
		15.80		30	0.52			10.00
		21.20			5 84			15.00
		25.80			10.49			20.00
		30.90			15.69			25.00
		35.90			20.60			30.00
		40.80			25.52			35.00
		45.90			30.59			40.00
		50.90			35.61			45.00
		55.90			40.61			50.00
	54	1.00			45.69			55.00
		6.00			50.70		48	0.00
		......			......			......
	55	6.10		31	51.05		49	0.00
		11.20			56.05			5.00
		16.20		32	1.00			10.00
		21.30			6.00			15.00
		26.30			11.05			20.00
		31.50			16.15			25.00
		36.40			21.10			30.00
		41.30			26.00			35.00

Washington clock. h.	m.	s.	Detroit clock. h.	m.	s.	Carlin chronometer. h.	m.	s.
17	55	46.20	17	32	30.90	10	49	40.00
		51.20			35.80			45.00
		56.50			41.20			50.00
	56	1.50			46.20			55.00
		6.30			51.00		50	0.00
	57	6.50		33	51.18		51	0.00
		11.50			56.20			5.00
		16.50		34	1.20			10.00
		21.60			6.40			15.00
		26.50			11.30			20.00
		31.40			16.18			25.00
		36.50			21.25			30.00
		41.40			26.00			35.00
		46.60			31.40			40.00
		51.60			36.39			45.00
		56.50			41.22			50.00
	58	1.70			46.40			55.00
		6.60			51.35		52	0.00
Mean, 17	55	44.24	17	32	28.97	10	49	37.97

MAY 23, 1871.—*Signals sent from Carlin.*

SECOND SERIES.

Washington clock. h.	m.	s.	Detroit clock. h.	m.	s.	Carlin chronometer. h.	m.	s.
18	26	11.20	18	2	56.00	11	20	0.00
		16.20		3	1.00			5.00
		21.20			5.99			10.00
		26.20			11.00			15.00
		31.30			16.00			20.00
		36.20			21.00			25.00
		41.10			25.92			30.00
		46.40			31.28			35.00
		51.50			36.33			40.00
		56.40			41.17			45.00
	27	1.60			46.40			50.00
		6.30			51.00			55.00
		11.30			56.12		21	0.00
		16.50		4	1.50			5.00
		26.50			11.30			15.00
		31.40			16.25			20.00
		36.40			21.29			25.00
		41.30			26.00			30.00
		46.60			31.40			35.00
		51.80			36.60			40.00
	28	1.60			46.40			50.00
		6.50			51.26			55.00
		11.40			56.12		22	0.00
		16.50		5	1.29			5.00
		21.40			6.29			10.00
		26 40			11.29			15.00
		31.50			16.37			20.00
		36.50			21.27			25.00
		41.60			26.60			30.00
		46.60			31.61			35.00
		51.60			36.69			40.00

Washington clock. h.	m.	s.	Detroit clock. h.	m.	s.	Carlin chronometer. h.	m.	s.
18	28	56.80	18	5	41.63	11	22	45.00
	29	1.70			46.81			50.00
		6.80			51.61			55.00
		11.60			56.41		23	0.00
		16.70		6	1.49			5.00
		21.60			6.39			10.00
		26.80			11.58			15.00
		31.60			16.45			20.00
		36.70			21.48			25.00
		41.70			26.51			30.00
		46.80			31.60			35.00
		51.80			36.64			40.00
		56.80			41.67			45.00
	30	2.00			46.80			50.00
		6.70			51.59			55.00
		11.80			56.70		24	0.00
		16.90		7	1.80			5.00
		21.70			6.50			10.00
		26.90			11.78			15.00
		32.00			16.80			20.00
		36.90			21.70			25.00
		41.90			26.70			30.00
		47.00			31.80			35.00
		52.20			37.00			40.00
		57.10			41.89			45.00
	31	2.30			47.18			50.00
		7.20			52.05			55.00
		12.10			56.95		25	0.00
Mean, 18	28	43.92	18	5	28.58	11	22	32.12

MAY 24, 1871.—*Signals sent from Washington.*

FIRST SERIES.

Washington clock.			Detroit clock.			Carlin chronometer.			Washington clock.			Detroit clock.			Carlin chronometer.		
h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
16	..	.....	16	..	.....	9	..	.....	16	56	50.00	16	33	37.60	9	46	54.10
		.....			......			......		57	0.00			47.80		47	4.20
		.....			......			......									
		.....			......			......		58	0.00		34	47.82		48	4.20
	54	30.00		31	17.90		44	34.30			10.00			57.76			13.90
		40.00			28.00			45.50			20.00		35	7.70			23.70
		50.00			37.69			54.20			30.00			17.69			33.60
											40.00			27.54			43.40
	56	.....		32	.....		46	.....			50.00			37.89			53.80
		.....			......			......		59	0.00			47.89		49	3.80
		.....		33	.....			......									
		30.00			17.70			34.00	Mean, 16	57	10.71	16	33	58.47	9	47	14.76
		40.00			27.65			43.90									

SECOND SERIES.

Washington clock.			Detroit clock.			Carlin chronometer.			Washington clock.			Detroit clock.			Carlin chronometer.		
h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
17	1	.....	16	37	.....	9	51	......	17	4	.....	16	40	47.86	9	54	3.00
				38	.....			......			10.00			57.80			12.80
		30.00			17.70			33.20									
		40.00			27.70			43.00		5	10.00		41	57.89		55	12.70
		50.00			37.79			53.30			20.00		42	7.79			22.60
	2	0.00			47.85		52	3.20			30.00			17.70			32.60
		10.00			57.89			13.20			......			......			.....
											50.00			37.71			52.60
	3	10.00		39	57.89		53	13.10		6	0.00			47.71		56	2.60
		20.00		40	7.62			22.30			10.00			57.90			12.60
		30.00			17.60			32.80									
		40.00			27.70			42.80	Mean, 17	3	49.44	16	40	37.21	9	53	52.33
		50.00			37.76			53.00									

THIRD SERIES.

Washington clock.			Detroit clock.			Carlin chronometer.			Washington clock.			Detroit clock.			Carlin chronometer.		
h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
17	26	0.00	17	2	48.00	10	15	59.60	17	26	40.00	17	3	27.93	10	16	39.50
		10.00			57.90		16	9.30			50.00			37.80			49.10
		20.00		3	7.68			19.20									
		30.00			17.85			29.30	Mean, 17	26	25.00	17	3	12.86	10	16	24.33

MAY 24, 1871.—*Signals sent from Carlin.*

FIRST SERIES.

Washington clock. h.	m.	s.	Detroit clock. h.	m.	s.	Carlin chronometer. h.	m.	s.
17	9	59.30	16	46	46.55	10	0	0.00
	10	4.40			51.70			5.00
		9.30			56.65			10.00
		14.40		47	1.70			15.00
		19.40			6.69			20.00
		24.50			11.81			25.00
		29.40			16.71			30.00
		31.20			21.51			35.00
		39.60			26.90			40.00
		44.70			32.00			45.00
		49.50			36.80			50.00
		54.50			41.88			55.00
		59.70			46.90		1	0.00
	11	4.60			51.91			5.00
		9.50			56.80			10.00
		14.60		48	1.90			15.00
		19.70			7.00			20.00
		24.70			12.00			25.00
		29.70			16.98			30.00
		34.60			21.92			35.00
		39.80			26.98			40.00
		44.60			31.87			45.00
		49.80			37.10			50.00
		54.80			42.00			55.00
		59.70			47.00		2	0.00
	12	4.70			52.00			5.00
		9.70			57.00			10.00
		......		49	......			......
		19.80			7.00			20.00
		24.70			11.95			25.00
		29.70			16.99			30.00
		34.70			21.99			35.00

Washington clock. h.	m.	s.	Detroit clock. h.	m.	s.	Carlin chronometer. h.	m.	s.
17	12	39.70	16	49	27.00	10	2	40.00
		44.90			32.28			45.00
		49.70			37.10			50.00
		54.80			42.15			55.00
		59.80			47.15		3	0.00
	13	4.90			52.20			5.00
		9.80			57.13			10.00
		14.80		50	2.10			15.00
		19.80			7.05			20.00
		24.80			12.10			25.00
		29.80			17.15			30.00
		35.10			22.45			35.00
		39.90			27.15			40.00
		44.90			32.15			45.00
		50.00			37.30			50.00
		54.10			42.39			55.00
		59.90			47.20		4	0.00
	14	5.00			52.21			5.00
		9.90			57.10			10.00
		15.10		51	2.30			15.00
		19.80			7.10			20.00
		24.90			12.15			25.00
		29.80			17.15			30.00
		35.20			22.50			35.00
		40.20			27.50			40.00
		45.10			32.38			45.00
		50.40			37.30			50.00
		55.10			42.39			55.00
	15	0.10			47.21		5	0.00
Mean, 17	12	30.06	16	49	17.29	10	2	30.25

SECOND SERIES.

Washington clock. h.	m.	s.	Detroit clock. h.	m.	s.	Carlin chronometer. h.	m.	s.
17	17	0.50	16	53	47.89	10	7	0.00
		5.70			52.81			5.00
		10.30			57.56			10.00
		15.50		54	2.79			15.00
		20.50			7.80			20.00
		25.30			12.53			25.00
		30.60			17.80			30.00
		35.30			22.61			35.00
		40.70			28.00			40.00
		45.70			33.00			45.00
		50.60			37.91			50.00
		55.70			42.90			55.00
	18	0.60			47.90		8	0.00
		5.60			53.10			5.00
		10.40			57.70			10.00
		......		55	......			......
		......			......			......
		25.70			12.88			25.00
		30.50			17.79			30.00
		35.60			22.90			35.00
		40.70			28.05			40.00
		45.70			33.00			45.00
		50.80			38.10			50.00
		55.80			43.10			55.00
	19	0.80			48.10		9	0.00
		5.80			53.10			5.00
		......			......			......
		......		56	......			......
		20.90			8.19			20.00
		25.90			13.20			25.00
		30.90			18.10			30.00
		36.00			23.22			35.00

Washington clock. h.	m.	s.	Detroit clock. h.	m.	s.	Carlin chronometer. h.	m.	s.
17	19	40.90	16	56	28.18	10	9	40.00
		46.00			33.21			45.00
		51.00			38.29			50.00
		56.00			43.30			55.00
	20	0.90			48.15		10	0.00
		5.90			53.19			5.00
		11.00			58.19			10.00
		16.10		57	3.33			15,00
		21.00			8.30			20.00
		26.00			13.70			25.00
		31.10			18.50			30.00
		36.10			23.55			35.00
		41.20			28.60			40.00
		46.10			33.49			45.00
		51.50			38.59			50.00
		56.20			43.70			55.00
	21	1.20			48.50		11	0.00
		6.20			53.52			5.00
		11.20			58.50			10.00
		16.20		58	3.50			15.00
		21.10			8.36			20.00
		26.40			13.72			25.00
		31.20			18.50			30.00
		......			......			......
		41.30			28.60			40.00
		46.20			33.48			45.00
		51.30			38.59			50.00
		56.40			43.70			55.00
	22	1.30			48.60		12	0.00
Mean, 17	19	31.88	16	56	19.00	10	9	30.98

May 23, 1871, I find one more set sent from Washington to Carlin, but not recorded at Detroit:

h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
17	21	10.00	10	15	10.80	17	47	......	10	41	......	17	49	30.00	10	43	26.00
		20.00			20.80			40.00			36.10			40.00			35.90
		......			......			50.00			46.30			50.00			45.90
		40.00			40.40		48	0.00			56.20		50	0.00			55.80
		50.00			50.30			10.00		42	6.20			10.00		44	5.80
	22	0.00		16	0.20			20.00			16.20			20.00			15.70
								30.00			26.10			......			......
												Mean, 17	40	56.47	10	34	53.81

And one set sent from Carlin to Washington, on the same date, recorded only at Washington and Carlin:

h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
18	1	37.40	10	55	30.00	18	3	7.80	10	57	0 00
		42.30			35.00			17.60			10.00
		47.30			40.00			22.70			15.00
		57.20			50.00			27.60			20.00
	2	2.40			55.00			32.60			25.00
		7.30		56	0.00			37.40			30.00
		12.80			5.00			42.60			35.00
		17.60			10.00			47.50			40.00
		22.70			15.00			52.60			45.00
		27.50			20.00			57.80			50.00
		32.30			25.00		4	7.60		58	0.00
		37.50			30.00	Mean, 18	2	51.22	10	56	43.70

Deduction of the results for longitude.

Date.	Signals sent from—	Washington clock.	Correction of Washington clock.	Local sidereal time of the mean of the signals.	Detroit clock.	Correction of Detroit clock.	Local sidereal time of the mean of the signals.	Carlin chronometer.	Correction of the Carlin chronometer.	Local sidereal time of the mean of the signals.	Carlin west of— Washington.	Carlin west of— Detroit.	Double-wave time for Carlin. Washington.	Double-wave time for Carlin. Detroit.	Final difference of longitude: Carlin west of— Washington.	Final difference of longitude: Carlin west of— Detroit.	Longitude of Detroit.
1871.		h. m. s.	s.	h. m. s.	h. m. s.	s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	s.	s.	h. m. s.	h. m. s.	h. m.
May 19	W. to C.	17 36 52.94	−0.72	17 36 52.22	17 13 23.78	−31.73	17 12 52.05	10 46 38.06	+4 13 57.58	15 0 35.64	2 36 16.58	2 12 16.41	[1.30]	[0.77]	2 36 17.23	2 12 16.80	0 24 0.43
May 23	W. to C.	17 40 56.47	+2.79	17 40 59.26				10 34 53.81	+4 29 48.76	15 4 42.57	16.69						
May 23	W. to C.	18 37 30.00	+2.75	18 37 32.75	18 14 15.15	42.40	18 13 32.75	11 31 18.02	58.02	16 1 16.04	16.71	16.71					
May 23	C. to W.	17 55 44.24	+2.78	17 55 47.02	17 32 28.97	−42.30	17 31 46.67	10 49 37.97	51.18	15 19 29.15	17.87	17.52					
May 23	C. to W.	18 2 51.22	+2.78	18 2 54.00				10 56 43.70	52.34	15 26 36.04	17.96						
May 23	C. to W.	18 28 43.92	+2.76	18 28 46.68	18 5 28.58	−42.38	18 4 46.20	11 22 32.12	56.58	15 52 28.70	17.98	17.50	1.24	0.80	17.32	17.11	0.21
May 24	W. to C.	16 57 10.71	+2.15	16 57 12.86	16 33 58.47	−45.35	16 33 13.12	9 47 14.76	+4 33 41.59	14 20 56.35	16.51	16.77					
May 24	W. to C.	17 3 49.44	+2.15	17 3 51.59	16 40 37.21	−45.36	16 39 51.85	9 53 52.33	42.68	14 27 35.01	16.58	16.84					
May 24	W. to C.	17 26 25.00	+2.16	17 26 27.16	17 3 12.86	−45.39	17 2 27.47	10 16 24.33	46.40	14 50 10.73	16.43	16.74					
May 24	C. to W.	17 12 30.06	+2.15	17 12 32.21	16 49 17.29	−45.37	16 48 31.92	10 2 30.25	44.01	14 36 14.26	17.95	17.66					
May 24	C. to W.	17 19 31.88	+2.15	17 19 34.03	16 56 19.00	−45.38	16 55 33.62	10 9 30.98	45.26	14 43 16.24	17.79	17.38	1.36	0.74	17.19	17.15	0.04

	h. m. s.	s.
Carlin west of Washington	2 36 17.25	±0.026
Carlin west of Detroit	2 12 17.02	±0.075
Detroit west of Washington	0 24 0.23	±0.076

Mean places of stars for 1871.0 *used for determination of latitude of Carlin, Nevada.*

No. of pair.	No. in B. A. C.	Declination.	No. of pair.	No. in B. A. C.	Declination.	No. of pair.	No. in B. A. C.	Declination.
		° ′ ″			° ′ ″			° ′ ″
	4526	25 1 2.73		4825	37 11 39.22		5234	18 32 30.71
1	4540	56 0 36.66	6	4841	44 11 57.58	11	5249	62 59 56.06
	4568	55 20 5.00		4885	42 55 27.50		5322	23 9 52.30
2	4594	26 21 2.56	7	4897	38 20 36.56	12	5348	58 54 37.13
	4640	29 17 1.25		4952	47 47 15.90		5385	36 49 12.83
3	4684	51 35 32.39	8	5000	33 34 10.00	13	5400	44 9 52.74
	4728	42 7 33.27		5071	....		5432	34 11 14.06
4	4758	39 23 16.50	9	5098	....	14	5463	46 37 18.00
	4804	50 25 22.70		5116	62 43 17.93			
5	4808	30 56 20.26	10	5146	18 5 14.96			

Observations for latitude.—Station, Carlin, Nevada.

Date.	No. of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.
1871. May 17	4568	12 52.2	13.5	10.0	
	4594	24 66.3	8.0	15.0	
	4640	7 94.7	11.0	12.5	
	4684	31 72.6	15.0	8.3	
	4804	17 35.8	9.8	14.0	
	4808	15 25.6	14.8	9.2	
25	4568	12 92.7	17.2	13.0	
	4594	25 8.0	12.4	18.0	
	4640	7 53.0	14.8	15.3	
	4684	31 30.9	17.0	13.9	
	4728	19 16.9	15.0	18.0	Mistake in reading,
	4758	23 16.7	16.8	15.0	to be excluded.
	4804	18 32.0	16.0	16.2	
	4808	16 8.2	13.2	18.8	
26	4526	11 73.6	17.0	10.0	
	4540	28 74.9	12.4	14.7	
	4568	9 59.0	14.2	12.8	
	4594	21 83.2	15.7	12.5	
	4640	1 45.3	14.8	14.0	
	4684	25 26.9	12.8	16.3	
	4728	16 20.4	13.0	16.0	
	4758	20 65.7	16.0	13.9	
	4804	17 52.5	9.8	21.0	
	4808	15 20.8	19.0	11.8	
	4825	11 91.2	7.2	23.5	
	4841	12 88.3	21.3	9.6	
	4885	25 6.7	16.2	15.0	
	4897	18 53.5	11.3	20.2	
	4952	15 66.2	9.2	19.8	
	5000	12 99.2	16.9	11.7	
	5071	1 62.5	13.0	15.2	
	5098	26 51.6	13.0	15.4	
	5116	33 23.9	17.8	10.5	
	5146	6 18.7	9.0	19.2	
	5234	20 74.2	17.8	11.2	
	5249	15 20.0	9.7	19.8	
1871. May 26	5322	32 51.6	13.8	16.4	
	5348	3 15.4	15.7	13.9	
	5385	9 64.8	13.2	16.2	
	5400	28 88.7	13.8	15.2	
	5432	4 41.7	16.2	13.2	
	5463	36 62.2	7.8	20.8	Must be 31^t.
27	4526	6 99.8	22.2	16.2	
	4540	24 6.0	17.8	20.5	
	4568	10 9.2	21.2	16.8	
	4594	22 22.8	15.8	22.7	
	4640	3 18.5	16.0	23.0	
	4684	27 8.0	20.0	19.5	
	4728	10 16.9	18.8	20.7	
	4758	13 78.9	17.5	22.0	Must be $14^t\ 58^d.9$.
	4804	13 22.2	18.0	22.0	
	4808	10 87.7	18.2	21.8	
	4825	14 9.3	19.0	21.2	
	4841	15 12.8	17.0	23.3	
	4885	19 69.4	18.8	22.0	Very faint.
	4897	13 5.0	17.6	23.0	
	4952	11 30.0	20.9	20.0	
	5000	8 52.9	13.7	....	Bubble beyond scale.
	5071	2 76.9	5.0	10.2	
	5098	27 51.0	2.3	13.0	
	5116	30 6.0	22.8	18.8	Mistake in reading,
	5146	3 54.7	20.7	21.3	excluded.
	5234	14 97.8	13.8	10.8	
	5249	9 75.9	0.0	21.0	Must be $9^t\ 45^d.9$.
	5322	32 87.0	12.0	9.8	
	5348	3 58.3	11.2	10.8	
	5385	5 11.1	18.3	15.7	
	5400	24 37.4	13.2	20.7	
	5432	4 36.0	14.0	23.0	
	5463	31 48.1	21.0	16.2	

Computations for latitude of Carlin, Nevada.

Date.	No. of pair.	Half-sum of declination.	Corrections. Micr. and ref.	Level.	Merid.	Latitude.
1871.		° ′ ″	′ ″	″		° ′ ″
May 17	2	40 50 37.68	− 8 11.00	− 2.36	....	40 42 24.32
	3	26 19.97	+16 1.70	+ 3.51	....	25.18
	5	40 53.23	+ 1 25.00	+ 0.95	....	19.18
May 25	2	40 50 39.29	− 8 11.49	− 0.95	....	40 42 26.85
	3	26 21.67	+16 1.69	+ 1.76	....	25.12
	4	45 29.14	− 2 61.68	− 0.81	....	[26.36]
	5	40 55.10	+ 1 30.50	− 3.92	....	21.68
May 26	1	40 30 55.63	+11 28.04	+ 3.17	....	40 42 26.84
	2	50 39.48	− 8 15.08	+ 3.10	....	27.50
	3	26 21.88	+16 3.18	− 1.82	....	23.24
	4	45 29.37	− 3 0.08	− 0.61	....	28.68
	5	40 55.33	+ 1 33.70	− 2.70	....	26.33
	6	41 52.30	+ 0 39.26	− 3.10	....	28.46
	7	38 5.52	+ 4 24.16	− 5.20	....	24.48
	8	40 44.81	+ 1 47.97	− 3.65	....	29.13
	9	59 17.83	−16 46.65	− 3.10	....	28.08
	10	24 17.32	+18 14.08	− 1.28	....	30.12
	11	46 13.38	− 3 44.13	− 2.36	....	26.89
	12	62 14.01	−19 47.47	− 0.27	....	26.27
	13	29 31.73	+12 58.04	− 2.97	....	26.80
	14	24 14.68	+18 20.25	− 6.75	....	28.18
May 27	1	40 30 55.82	+11 30.02	+ 2.23	....	40 42 28.07
	2	50 39.69	− 8 10.80	− 1.69	....	27.20
	3	26 22.09	+16 6.37	− 4.39	....	24.07
	4	45 29.61	− 2 58.75	− 4.32	....	26.54
	5	40 55.56	+ 1 34.83	− 5.13	....	25.26
	6	41 52.57	+ 0 41.85	− 5.74	....	28.68
	7	38 5.77	+ 4 28.69	− 5.80	....	28.66
	8	40 45.05	+ 1 52.05	− 8.50	....	28.60
	9	59 18.07	−16 40.59	−10.73	....	26.75
	10	24 17.55	−18 12.51	+ 2.30	....	[32.36]
	11	46 13.54	− 3 43.24	− 5.40	....	24.90
	12	62 14.30	−19 44.44	+ 1.76	....	31.62
	13	29 32.00	+12 59.01	− 3.31	....	27.70
	14	24 14.94	+18 16.85	− 2.83	....	28.96

Mean, 40° 42′ 26″.67 ± 0″.28.

We conclude, therefore, that the longitude of Carlin station is 39° 04′ 18″.80 west of Washington, or 116° 07′ 20″.6 west of Greenwich, and the latitude = N. 40° 42′ 26″.67.

BATTLE MOUNTAIN, NEVADA.

Geographical position of station: Longitude, 116° 56′ 13″.50; latitude, 40° 38′ 18″.74 ±0″.21.

The astronomical station is situated near Battle Mountain, Nev., a town on the Central Pacific Railroad. The track of the railroad runs at this point in a nearly north and south direction. The astronomical monument is placed southeastward from the town, and 1,475 feet east of the track, and 1,166 feet from the public-school building. Battle Mountain has about 800 inhabitants. The astronomical station is but slightly elevated above the railroad-track; the place is level, but at a distance of one mile prominent hills and ridges, rising 3,000 feet above the station, are visible. The elevation of the station is determined to be, approximately, 4,500 feet above the level of the sea.

Meteorological conditions.—No detailed meteorological observations were taken at this station. From the diary of the observer it can be seen that it was cloudy almost always during the day, but clear at night. The observer lost much time waiting for the line to Detroit. On some

days only very few observations for latitude were taken, after he had waited until late at night expecting to get the use of the wires for longitude-work.

Description of observatory and instruments used.—The construction of the observatory was the same as at Carlin, and a description of it will be found in the report for that station.

The same instruments for time-determination and exchange of signals were also used. For the latter purpose the wires of the Western Union Telegraph Company were employed. The observer, E. P. Austin, was assisted at this point by two enlisted men.

Points with which connections were made.—It was intended to connect Battle Mountain with Washington and Detroit, but it was impracticable to connect with Washington, and the exchange of signals was made with Detroit only, where Mr. O. B. Wheeler, assistant United States lake-survey, conducted both observations and computations.

An explanation of the signs and symbols used in the determination of time at Detroit will be found in the report for Carlin station. The observations made at Battle Mountain were reduced in 1873 by Dr. F. Kampf, and revised in 1874. The arrangement of the report was also made by him.

Instrumental values, &c.—The instrumental values are given in the report for Carlin station. The signals were sent by sound from Battle Mountain, and recorded by eye and ear. At Detroit they were sent by sound also, but recorded on a chronograph. By means of automatic repeaters at Corinne, Cheyenne, Omaha, and Chicago, the signals were transmitted direct to the connected stations.

It has been found impossible to get a better result for longitude. The observer used for temporary monuments pieces of wood buried in the ground, which proved too unsteady to give the most accurate results. These temporary monuments were replaced later by a sandstone pier.

Computation of clock-correction for Detroit, June 1, 1871.

Ill.	Star.	C i	Aberr.	B b	C c	t′	a	(a − t)	v
		s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.	s.
W.	α Serpentis	+.03	−.01	+ .23	+ .11	15 39 04.91	15 37 56.36	−1 08.91	+.08
	ε Serpentis	+.03	−.01	+ .20	+ .10	45 33.21	44 24.71	08.82	− 02
	ζ Ursæ Minoris	+.16	−.07	+ .94	+ .51	49 56.06	48 49.16	08.44	.....
	ε Coronæ Borealis	+.03	−.02	+ .24	+ .12	53 24.93	52 16.53	08.77	−.03
	β Scorpii	+.03	−.02	+ .10	+ .11	59 06.39	57 57.91	08.70	−.22
	δ Ophiuchi	+.03	−.01	+ .12	+ .10	16 08 45.31	16 07 36.71	08.84	−.06
	τ Herculis	+.04	−.02	+ .27	+ .15	17 02.15	15 53.74	08.85	+.08
W.	κ Ophiuchi	+.03	−.24	+ .21	+ .11	52 44,06	51 35.27	09.13	+.20
E.	δ Ursæ Minoris	....	−.24	..2.18	−1.76	18 15 23.94	18 14 17.23	06.89	.....
	1 Aquilæ	−.03	−.01	+ .12	− .11	29 21.54	28 12.61	08.90	−.23
	ζ Aquilæ	−.03	−.01	+ .19	− .11	19 00 39.26	59 30.13	09.17	+.05
	ω Aquilæ	−.03	−.01	+ .19	− .11	12 56.11	19 11 46.95	09.20	+.06
	δ Aquilæ	−.03	−.01	+ .16	− .10	20 10.03	19 00 85	09.20	+.03
	γ Aquilæ	−.03	−.01	+ .19	− .11	41 17.97	40 08.78	09.23	+.04
	α Aquilæ	−.03	−.01	+ .19	− .11	45 39.61	44 30.50	09.15	−.05
E.	β Aquilæ	−.03	−.01	+ .19	− .11	50 08.92	48 59.71	09.25	+.04

Normal equations.

$$+151.98\,a + 0.96\,\rho - 6.88\,\delta\theta + 19.62 = 0$$
$$+0.96\,a + 42.91\,\rho - 3.57 = 0$$
$$-6.88\,a + 16.00\,\delta\theta + 13.45 = 0$$

$a = -0^s.17$

$c = -0^s.10$, lamp east.

$\rho = +0^s.087$, per hour.

$\Delta t = -1^m\,08^s.91 \pm 0^s.021$, at $17^h\,38^m$.

Computation of clock-correction for Detroit, June 3, 1871.

Ill.	Star.	C Δ i	Aberr.	B b	C c	t′	a	(a − t)	v
		s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.	s.
E.	ε Coronæ Borealis	−.04	−.02	+ .21	−.03	15 53 30.18	15 52 16.54	−1 13.76	+.32
	β Scorpii	−.03	−.02	+ .10	−.03	58 11.40	57 57.93	13.49	+.08
	δ Ophiuchi	−.03	−.01	+ .13	−.03	16 08 50.28	16 07 36.73	13.61	+.15
	ξ Ophiuchi	−.03	−.01	+ .10	−.03	31 18.13	30 05.02	13.44	−.10
	ξ Herculis	−.04	−.02	+ .19	−.03	37 40.56	36 27.16	13.50	−.10
	η Herculis	−.04	−.02	+ .20	−.03	39 43.82	38 30.30	13.63	+.01
	α Ophiuchi	−.03	−.01	+ .13	−.03	17 30 12.10	17 28 58.34	13.82	+.07
E.	δ Ursæ Minoris	....	−.24	+1.19	−.64	18 15 31.93	18 14 17.33	14.91	......
W.	δ Ursæ Minoris	....	−.24	+1.88	+.64	29.96	....	14.91	......
	1 Aquilæ	+.03	−.01	+ .09	+.03	29 26.39	28 12.65	13.88	−.06
	ξ Aquilæ	+.03	−.01	+ .09	+.03	19 00 44.14	59 30.17	14.11	+.06
	d Sagittarii	+.03	−.02	+ .05	+.03	11 20.41	19 10 06.58	13.92	−.14
	ω Aquilæ	+.03	−.01	+ .07	+.03	13 00.93	11 46.99	14.06	−.04
	δ Aquilæ	+.03	−.01	+ .06	+.03	20 14.73	19 00.90	13.94	−.17
	γ Aquilæ	+.03	−.01	+ .16	+.03	41 22.71	40 08.83	14.09	−.10
W.	α Aquilæ	+.03	−.01	+ .21	+.03	45 44.57	44 30.55	−1 14.28	+.08

Normal equations.

$$+144.49\,a + 3.96\,\rho - 3.72\,\delta\theta - 15.88 = 0$$
$$+3.96\,a + 29.78\,\rho - 5.67 = 0$$
$$-3.72\,a + 15.00\,\delta\theta + 13.44 = 0$$

$a = +0^{s}.08.$

$c = +0^{s}.03$, lamp east.

$\rho = +0^{s}.201$, per hour.

$\Delta t = -1^{m}\,13^{s}.86 \pm 0^{s}.024$, at $17^{h}\,50^{m}$

Computation of clock-correction for Detroit, June 10, 1871.

Ill.	Star.	C Δ i	Aberr.	B b	C c	t′	a	(a−t)	v
		s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.	s.
E.	α Bootis	−.03	−.02	+ .13	−.03	14 11 09.32	14 09 47.84	−1 21.53	+.08
	ρ Bootis	−.04	−.02	+ .15	−.03	27 39.02	26 17.59	21.49	+.10
	ε Bootis	−.03	−.02	+ .14	−.03	40 44.04	39 22.60	21.50	+.09
	α² Libræ	−.03	−.02	+ .07	−.03	45 07.50	43 46.10	21.39	−.19
E.	β Ursæ Minoris	....	−.05	+ .42	−.10	52 30.36	51 10.30	20.33	......
W.	β Ursæ Minoris	....	−.05	+ .71	+.10	30.95	....	20.51	......
	β Libræ	....	−.01	+ .14	+.03	15 11 26.75	15 10 05.50	21.41	−.15
	μ¹ Bootis	+.03	−.02	+ .28	+.03	20 59.72	19 38.74	21.30	−.06
	α Serpentis	+.03	−.02	+ .18	+.03	39 17.67	37 56.38	21.51	.00
	ε Serpentis	+.03	−.01	+ .18	+.03	45 46.17	44 24.74	21.66	+.15
	Ursæ Minoris	+.16	−.07	+ .88	+.13	50 08.03	48 48.83	20.30	......
	β¹ Scorpii	....	−.02	+ .11	+.03	59 19.29	57 57.97	21.44	−.17
	ζ Ophiuchi	+.03	−.01	+ .13	+.03	16 31 26.46	16 30 05.08	21.56	−.02
	κ Ophiuchi	+.03	−.01	+ .17	+.03	52 56.73	51 35.35	21.60	+.09
	ε Ursæ Minoris	+.24	−.10	+1.12	+.19	17 00 44.49	59 25.78	20.16	......
W.	α¹ Herculis	+.03	−.01	+ .17	+.03	10 09.00	17 08 47.59	21.63	+.14
W.	η Serpentis	+.03	−.01	+ .12	+.03	18 16 01.00	18 14 39.64	21.53	−.04
W.	51 Cephei, L. C	......	+.29	−3.06	−.53	40 18.12	6 38 49.29	25.53	......
E.	51 Cephei, L. C	....	+.29	− .65	+.53	14.64	....	.52	......
	ζ Aquilæ	−.03	−.01	+ .06	−.03	19 00 51.88	59 30.32	21.55	+.04
	d Sagittarii	−.03	−.02	+ .05	−.03	11 28.38	19 10 06.75	21.60	−.05
	ω Aquilæ	−.03	−.01	+ .10	−.03	13 08.75	11 47.14	21.64	+.12
	δ Aquilæ	−.03	−.01	+ .10	−.03	20 22.64	19 01.05	21.62	−.03
E.	κ Aquilæ	−.03	−.01	+ .10	−.03	31 19.97	29 58.46	−1 21.54	−.06

Normal equations.

$$+296.13\,a - 38.83\,\rho + 17.03\,\delta\theta + 84.99 = 0$$
$$-38.83\,a + 69.42\,\rho - 12.35 = 0$$
$$+17.03\,a + 22.00\,\delta\theta + 11.92 = 0$$

$a = -0^{s}.03$

$c = -0^{s}.03$, lamp east.

$\rho = +0.009$, per hour.

$\Delta t = -1^{m}.\,21^{s}.34 \pm 0^{s}.017$ at $16^{h}\,42^{m}$

Battle Mountain, Nev., June 1, 1871.

Name of star.	Clamp.	T	bB	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
α Virginis	W.	13 17 5.98	+ 0.02	+ 3.23	+ 0 42	13 17 9.65	13 18 25.01	+ 1 15.36
ζ Virginis	....	26 49.52	+ 0.08	+ 2.66	+ 0.41	26 52.67	28 8.32	15.65
η Ursæ Majoris..	....	41 13.48	+ 0.26	− 1.02	+ 0.64	41 13.36	42 28.88	15.52
η Bootis	....	47 16.24	+ 0.18	+ 1.60	+ 0.43	47 18.45	48 33.74	15.29
50 Cap., L. C......	....	50 59.16	− 0.23	+12.11	− 1.31	51 9.73	52 25.27	15.54
τ Herculis	E.	16 14 39.59	− 0.36	− 0.61	− 0.60	16 14 38.02	16 15 53.75	15.73
α Scorpii	....	20 12.34	− 0.11	+ 4.17	− 0.46	20 15.94	21 31.80	15.86
15 Draconis.......	....	27 10.04	− 0.54	− 5.44	− 1.15	27 2.91	28 18.51	15.60
α Camelop., L. C .	....	39 44.96	+ 0.14	+ 9.65	+ 1.01	39 55.76	41 11.40	15.64
ε Ursæ Minoris..	....	58 35.38	− 1.21	−20.12	− 3.04	58 11.01	59 25.98	+ 1 14.97
Mean for 15^h 0^m local sidereal time								+ 1 15.52

Four different computations to find the error of chronometer were made. The error of collimation adopted from two computations = $-0^s.41$. The method of least squares gave an unsatisfactory result; the azimuth of the instrument was therefore computed from polar and south stars = $+4^s.09$. β Draconis is excluded in the above determination of time, as it gives a result differing too much from those of the other stars.

Battle Mountain, Nev., June 3, 1871.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
ζ Virginis.......	W.	13 26 52.96	− 0.16	+ 0.33	+ 0.32	13 26 53.45	13 28 8.31	+1 14.86
η Ursæ Majoris..	....	41 13.50	− 0.11	− 0.13	+ 0.50	41 13.76	42 28.85	15.09
η Bootis	....	47 18.44	− 0.12	+ 0.20	+ 0.34	47 18.86	48 33.74	14.88
50 Cassiop., L. C ..	....	51 9.85	+ 0.20	+ 1.50	− 1.02	51 10.53	52 25.39	14.86
α Draconis	....	59 41.45	− 0.35	− 0.49	+ 0.86	59 41.47	14 0 46.21	+1 14.74
Mean for 13^h 45^m local sidereal time								+1 14.886

Normal equations.

$$0 = -0.23 + 5.00\,\delta t + 2.78\,a \qquad \delta t = -0^s.115$$
$$0 = -2.86 + 2.78\,\delta t + 10.33\,a \qquad a = +0^s.308$$

By preliminary reduction the error of collimation is found = $-0^s.32$; adopted error of azimuth = $+0^s.20$. The azimuth of the instrument found by the method of least squares = $+0^s.508$.

Battle Mountain, Nev., June 3, 1871.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
δ Corvi	E.	12 22 51.52	−0.02	+5.84	−0.33	12 42 57.01	12 23 12.00	+1 12.99
κ Draconis.......	....	26 55.48	−0.08	−9.99	−0.96	26 44.45	27 59.50	15.05
γ Virginis	....	33 49.00	−0.04	+4.43	−0.32	33 53.07	35 8.07	15.00
35 Virginis	....	40 59.21	−0.06	+4.02	−0.32	41 2.85	41 18.10	15.25
12 Canum Venat..	....	48 45.52	−0.14	+0.27	−0.41	48 45.24	50 0.39	15.15
θ Virginis	....	54 28.28	−0.12	+3.35	−0.33	54 31.18	55 46.32	15.0
Virginis	....	13 1 57.84	−0.10	+4.83	−0.32	13 2 2.25	13 3 17.30	+1 15.6
Mean for 12^h 40^m local sidereal time								+1 15.09

Normal equations.

$$0 = +0.05 + 7.00\,\delta t + 1.90\,a \qquad \delta t = -0^s.01$$
$$0 = -0.02 + 1.90\,\delta t + 4.55\,a \qquad a = +0^s.009$$

The error of collimation is found by preliminary reduction.......... = $-0^s.32$
The azimuth was determined by δ Corvi and κ Draconis............. = $+6^s.70$
And by mean of the least squares the azimuth is given .... = $+6^s.70$

Battle Mountain, Nev., June 10, 1871.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.
ζ Ursa Minoris ..	W.	15 47 41.85	−2.25	+0.40	+0.06	15 47 40.06	15 48 48.84	+1 8.78
δ Scorpii	....	51 35.88	−0.24	−0.13	+0.01	51 35.52	52 44.21	8.69
β¹ Scorpii	....	56 49.56	−0.29	−0.12	+0.01	56 49.16	57 57.97	8.81
Groom. 2320....	....	16 4 54.42	−1.43	+0.17	+0.03	16 4 53.19	16 6 2.00	8.41
τ Herculis	....	14 45.42	−0.83	+0.02	+0.02	14 44.63	15 53.76	9.13
α Scorpii	....	20 23.40	−0.24	−0.13	+0.01	20 23.04	21 31.88	8.84
Mean for 16^h 0^m local sidereal time								+1 8.84

Normal equations.

$$0 = +0.59 + 6.00\,\delta t - 1.47\,a - 12.29\,c \qquad t = -0^s.16$$
$$0 = +1.73 - 1.47\,\delta t + 13.47\,a + 13.71\,c \qquad a = -0^s.133$$
$$0 = +0.36 - 12.28\,\delta t + 13.71\,a + 36.75\,c \qquad c = -0^s.012$$

From the preceding observations, the following table containing corrections of chronometer and adopted rates for Negus No. 1344 is derived.

1871.	h.		m. s.		s.
June 1,	15.0 local sidereal time:	cor. of chronometer,	+ 1 15.52;	adopted rate,	+ 0.011
June 3,	13.2 local sidereal time:	cor. of chronometer,	+ 1 14.99;	adopted rate,	+ 0.023
June 10,	14.8 local sidereal time:	cor. of chroaometer,	+ 1 8.84;	adopted rate,	+ 0.035

Before and after exchange, comparisons of Negus 1344 and Hutton 288 (mean solar chronometer) were made, as follows:

1871.	h. m. s.	h. m. s.	h. m. s.
June 1. Negus 1374....................	13 56 30.0	13 59 34.0	
Hutton 288....................	8 55 57.5	8 58 51.0	
After exchange:			
Negus 1344....................	15 57 56.0	16 00 59.0	16 4 6.0
Hutton 288....................	10 56 53.5	10 59 56.0	11 3 2.5
June 3. Negus 1344....................	14 5 2.0	14 8 5.0	
Hutton 288....................	8 56 25.0	8 59 27.5	
After exchange:			
Negus 1344....................	15 0 40.5	15 3 44.0	15 6 49.0
Hutton 288....................	9 51 54.0	9 54 57.0	9 58 1.5
June 10. Negus 1344....................	14 14 13.0	14 17 17.0	
Hutton 288....................	8 37 57.0	8 41 0.5	
After exchange:			
Negus 1344....................	15 38 24.0	15 41 26.0	
Hutton 288....................	10 1 54.0	10 4 55.5	

From these comparisons the following table for mean-time chronometer Hutton 288 is derived.

Hutton 288.

	Hutton time.	Slow of sidereal time.	Losing per hour.	Log.
	h.	h. m. s.	s.	
June 1, 1871....................	8.95535	5 1 58.28	9.898	0.9955363
	10.99925	2 18.51		
June 3, 1871....................	8.96562	9 52.20	10.249	1.0106754
	9.91597	10 1.94		
June 10, 1371....................	8.65799	37 25.11	9.949	0.9977580
	10.06021	37 39.06		

Exchange of signals between Detroit, Mich., and Battle Mountain, Nev.

JUNE 1, 1871.—*Signals sent from Detroit.*

Detroit clock.	Battle Mountain chronometer.	Detroit clock.	Battle Mountain chronometer.	Detroit clock.	Battle Mountain chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
17 22 40.25	10 3 49.80		10 5	17 26 20.05	10 7 29.00
50.06	50.60	17 24 40.10	49.30	30.20	39.00
23 0.35	4 9.80	50.20	59.10	40.20	49.00
		25 0.24	6 9.40	50.15	59.00
24 0.21	5 9.80			27 0.21	8 9.00
10.03	19.20	26 0.25	7 9.30		
20.05	29.20	10.19	19.00	Mean, 17 25 3.92	10 6 13.03

SECOND SERIES.

Detroit clock.	Battle Mountain chronometer.	Detroit clock.	Battle Mountain chronometer.	Detroit clock.	Battle Mountain chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
17 52 40.29	10 33 44.80	17 54 50.10	10 35 54.40	17 57 0.05	10 38 4.00
50.21	54.70	55 0.08	36 4.30	10.05	14.00
53 0.21	34 4.60	10.18	14.30	20.10	23.90
10.20	14.50	20.10	24.00	30.20	33.90
20.15	24.50	30.20	34.10	40.10	44.00
30.20	34.50	40.20	44.20		
40.11	44.50			Mean, 17 55 10.14	10 36 14.26
		56 40.05	37 43.90		
54 40.08	35 44.30	50.14	54.00		

Signals sent from Battle Mountain.

Detroit clock.	Battle Mountain chronometer.	Detroit clock.	Battle Mountain chronometer.	Detroit clock.	Battle Mountain chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
17 40 24.31	10 22 10.00	17 44 54.92	10 26 40.00	17 46 15.10	10 28 0.00
29.50	15.00	59.95	45.00	20.05	5.00
34.22	20.00	45 4.90	50.00	25.12	10.00
39.31	25.00	9.92	55.00	30.25	15.00
44.28	30.00	14.91	27 0.00	35.20	20.00
49.45	35.00	19.90	5.00	40.50	25.00
54.60	40.00	24.98	10.00	45.35	30.00
		30.10	15.00	50.30	35.00
41 14.88	26 0.00	35.15	20.00	55.31	40.00
19.69	5.00	40.40	25.00	47 0.20	45.00
24.80	10.00	45.10	30.00	5.19	50.00
29.90	15.00	50.27	35.00	10.30	55.00
34.88	20.00	55.06	40.00	15.20	29 0.00
39.92	25.00	46 0.20	45.00		
45.00	30.00	5.18	50.00	Mean, 17 44 56.44	10 26 41.48
49.75	35.00	10.06	55.00		

JUNE 3, 1871.—*Signals sent from Detroit.*

Detroit clock.	Battle Mountain chronometer.	Detroit clock.	Battle Mountain chronometer.	Detroit clock.	Battle Mountain chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
16 41	9 14	16 43 10.12	9 16 28.80	16 45 20.05	9 18 38.40
10.25	29.10	20.08	38.60	30.25	48.50
20.00	39.00	30.10	48.60	40.12	58.50
30.15	49.10	40.20	58.70	50.12	19 8.30
40.25	59.10	50.29	17 8.60	46 0.40	18.50
50.37	15 9.20	44 0.30	18.80		
42 0.25	19.00			Mean, 16 43 37.70	9 16 56.24
		45 0.28	18 18.60		
43 0.38	16 19.00	10.08	28.40		

SECOND SERIES.

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
17	0	0.25	9	31	16.50	17	2	10.20	9	33	25.80	17	4	20.20	9	35	35.40
		10.05			26.10			20.18			35.80						......
		20.13			36.20			30.15			45.80			40.18			55.50
		30.21			46.30			40.21			55.80			50.25		36	5.40
		40.11			56.00			50.13		34	6.00		5	0.20			15.20
		50.23		32	6.00		3	0.18			16.00						
	1	0.41			16.00							Mean, 17	2	24.19	9	33	39.83
							4	0.10		35	15.40						
	2	0.30		33	15.90			10.20			25.50						

Signals sent from Battle Mountain.

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
16	49	43.23	9	23	0.00	16	51	28.72	9	24	45.00	16	53	13.93	9	26	30.00
		48.30			5.00			33.45			50.00			19.05			35.00
		53.12			10.00			38.60			55.00			23.88			40.00
		58.20			15.00			43.70		25	0.00			28.80			45.00
	50	3.30			20.00			48.70			5.00			33.90			50.00
		8.83			25.00			53.59			10.00			38.85			55.00
		13.50			30.00			58.59			15.00			43.82		27	0.00
		18.61			35.00		52	3.85			20.00			48.90			5.00
		23.68			40.00			8.83			25.00			53.80			10.00
		28.68			45.00			13.81			30.00			59.10			15.00
		33.45			50.00			18.89			35.00		54	4.10			20.00
		38.60			55.00			23.78			40.00			9.34			25.00
		43.42		24	0.00			28.71			45.00			14.10			30.00
		48.41			5.00			33.74			50.00			19.20			35.00
		53.45			10.00			38.59			55.00			24.36			40.00
		58.55			15.00			43.60		26	0.00			29.20			45.00
	51	3.50			20.00			48.68			5.00			34.08			50.00
		8.82			25.00			53.70			10.00			39.15			55.00
		13.60			30.00			58.75			15.00			44.00		28	0.00
		18.70			35.00		53	3.71			20.00						
		23.70			40.00			8.95			25.00	Mean, 16	52	13.75	9	25	30.00

JUNE 10, 1871.—*Signals sent from Detroit.*

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
17	12	......	9	17	......	17	14	10.00	9	19	44.80	17	16	20.10	9	21	54.60
		10.10			45.10			20.15			54.90			30.10		22	4.50
		20.25			55.40			30.10		20	4.90			40.10			14.40
		30.20		18	5.40			40.10			14.90			50.15			24.20
		40.45			15.50			50.20			24.80		17	0.55			34.10
		50.20			25.10		15	0.10			34.60						
	13	0.20			35.10							Mean, 17	14	37.69	9	20	12.32
							16	0.43		21	34.60						
	14	0.25		19	35.10			10.10			44.40						

SECOND SERIES.

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.	h.	m.	s.
17	26	30.24	9	32	3.00	17	28	40.21	9	34	12.60	17	30	50.15	9	36	22.00
		40.00			12.70			50.21			22.50		31	0.00			32.00
		50.20			22.70			59.84			32.20			10.26			42.10
	27	0.20			32.70		29	10.12			42.40			20.10			52.00
		10.10			42.60			20.15			52.40			30.30		37	2.10
		20.12			52.50			30.21		35	2.40						
		30.10		33	2.60							Mean, 17	29	0.15	9	34	32.40
							30	30.21		36	2.20						
	28	30.27		34	2.60			40.18			12.20						

Signals sent from Battle Mountain.

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
17	19	26.69	9	25	0.00	17	21	6.93	9	26	40.00	17	22	47.29	9	28	20.00
		31.75			5.00			12.08			45.00			52.38			25.00
		36.60			10.00			17.20			50.00			57.30			30.00
		41.80			15.00			21.86			55.00		23	2.46			35.00
		46.90			20.00			27.08		27	0.00			7.42			40.00
		51.84			25.00			32.01			5.00			12.49			45.00
		56.88			30.00			36.82			10.00			17.45			50.00
	20	1.92			35.00			41.90			15.00			22.50			55.00
		7.15			40.00			47.18			20.00			27.55		29	0.00
		12.10			45.00			51.92			25.00			32.41			5.00
		17.03			50.00			57.25			30.00			37.48			10.00
		22.00			55.00		22	2.15			35.00			42.40			15.00
		26.90		26	0.00			7.24			40.00			47.62			20.00
		32.00			5.00			12.45			45.00			52.55			25.00
		37.00			10.00			17.25			50.00			57.50			30.00
		41.96			15.00			22.50			55.00		24	2.72			35.00
		46.95			20.00			27.35		28	0.00						
		51.95			25.00			32.35			5.00	Mean, 17	21	44.66	9	27	17.50
		56.98			30.00			37.32			10.00						
	21	2.00			35.00			42.30			15.00						

Deduction of the results for longitude.

Date.	Signals sent from—	Detroit clock.	Clock correction.	Local sidereal time of the mean of the signals.	Battle Mountain chronometer.	Correction of chronometer.	Local sidereal time of the mean of the signals.	Differences of longitude.	Mean.	Double-wave time.	Final differences of longitude.
		h. m. s.	m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	s.	s.	h. m. s.
June 1, 1871	Detroit to Battle Mountain.	17 25 3.92	−1 8.91	17 23 55.01	10 6 13.03	+5 2 9.65	15 8 22.68	2 15 32.33	......	......	....
June 1, 1871	Detroit to Battle Mountain.	17 55 10.14	1 8.94	17 54 1.20	10 36 14.26	2 14.60	15 38 28.86	32.34	32.34	......	....
June 1, 1871	Battle Mountain to Detroit.	17 44 56.44	1 8.92	17 43 47.52	16 26 41.48	2 13.02	15 28 54.50	33.02	33.02	0.68	2 15 32.68
June 3, 1871	Detroit to Battle Mountain.	16 43 37.70	−1 13.64	16 42 24.06	9 16 56.24	+5 9 55.45	14 26 51.69	32.37	......	......	....
June 3, 1871	Detroit to Battle Mountain.	17 2 24.19	1 13.69	17 1 10.50	9 33 39.83	9 58.30	14 43 38.13	32.37	32.37	......	....
June 3, 1871	Battle Mountain to Detroit.	16 52 13.75	1 13.67	16 51 0.08	9 25 30.00	9 56.91	14 35 26.91	33.17	33.17	0.80	32.77
June 10, 1871	Detroit to Battle Mountain.	17 14 37.69	−1 21.34	17 13 16.35	9 20 12.32	+5 37 31.87	14 57 44.19	32.16	......	......	....
June 10, 1871	Detroit to Battle Mountain.	17 29 0.15	1 21.35	17 27 38.80	9 34 32.40	37 34.24	15 12 6.64	32.16	32.16	......	....
June 10, 1871	Battle Mountain to Detroit.	17 21 44.66	1 21.34	17 20 23.32	9 27 17.50	37 33.04	15 4 50.54	32.78	32.78	0.62	32.47

Battle Mountain west of Detroit $2^h\ 15^m\ 32^s.64 \pm 0^s.06$.

Mean places of stars for 1871.0 *used for determination of latitude of Battle Mountain, Nev.*

No. of pair.	No. in B. A. C.	Declination.	No. of pair.	No. in B. A. C.	Declination.	No. of pair.	No. in B. A. C.	Declination.
		° ′ ″			° ′ ″			° ′ ″
1	4568	55 20 5.00	7	4825	37 11 39.22		5385	36 49 12.83
	4594	26 21 2.56		4841	44 11 57.58	13	5400	44 9 52.74
2	4605	55 4 38.28	8	4863	37 16 26.30			
						14	5432	34 11 14.06
	4640	29 17 1.25		4952	47 47 15.90		5463	46 37 18.00
3	4684	51 35 32.39	9	5000	33 34 10.00	15	5479	34 6 14.86
	4694	31 28 3.52		5072	33 23 49.53		5541	30 46 15.72
4	4701	50 4 5.00	10	5113	48 9 26.29	16	5549	50 24 52.85
	4723	29 42 34.42		5157	43 35 44.60		5596	49 10 53.84
5	4752	51 54 18.25	11	5178	37 3 21.00	17	5604	31 50 17.80
	4804	50 25 22.70		5252	21 22 3.96		5752	56 52 42.77
6	4808	30 56 20.26	12	5307	59 17 3.64	18	5798	24 23 49.00

Observations for latitude.—Station, Battle Mountain, Nev.

Date.	No. of star.	Micrometer-readings.		Level. N.	Level. S.	Remarks.
1871.		*t.*	*d.*			
June 6	5432	1	41.5	18.2	15.5	
	5463	22	13.9	18.5	15.2	
	5479	−2	34.4	18.2	15.8	
	5541	12	62.2	17.5	16.8	
	5549	16	49.0	22.0	12.0	
June 7	5252	7	48.2	17.0	15.0	
	5307	35	8.2	18.0	13.8	
	5385	11	72.2	21.8	10.2	
	5400	24	59.5	12.8	19.0	
	5432	13	81.0	15.6	15.0	
	5463	34	47.8	20.0	12.8	
	5479	10	19.2	16.3	16.3	
	5541	18	53.0	20.3	13.0	
	5549	22	35.3	18.0	15.0	
June 8	4568	11	10.0	12.0	10.5	
	4594	29	47.0	12.0	10.5	
	4605	22	55.8	10.7	12.0	
	4640	11	88.8	10.2	12.2	
	4684	29	50.3	13.0	10.2	
	4694	26	51.0	15.5	8.0	
	4701	14	83.6	8.0	16.0	
	4723	23	28.0	12.6	11.8	
	4752	5	48.9	14.0	10.3	Is No. 4742.
	4825	23	27.9	14.8	10.0	
	4841	17	78.8	14.0	10.5	
	4863	28	28.0	14.0	11.0	
	5072	24	9.1	11.8	11.8	
	5113	11	63.6	12.8	11.8	
	5157	32	29.5	15.0	9.5	
	5178	4	65.3	10.0	14.8	
1871.		*t.*	*d.*			
June 8	5252	7	91.0	15.0	10.0	
	5307	35	67.0	10.0	15.0	
	5385	8	97.8	13.0	12.5	
	5400	26	90.5	14.8	11.0	Must be 21t.
	5432	13	76.8	15.8	10.0	
	5463	34	43.5	12.8	13.0	
	5479	10	1.6	15.8	10.0	
	5541	18	16.2	9.5	16.8	
	5549	21	98.9	21.2	5.0	
	5596	25	79.9	12.0	14.0	
	5604	14	51.0	17.5	8.8	
	5752	23	64.8	17.8	9.2	
	5798	23	83.8	17.0	10.2	
June 9	4568	9	86.2	12.0	11.0	
	4594	28	12.0	8.0	15.8	
	4640	10	87.9	13.5	10.3	
	4684	28	79.0	4.0	20.8	
	4694	26	40.2	6.2	18.8	
	4701	14	80.0	17.0	8.0	
	4723	25	68.9	11.2	13.5	Must be 23t.
	4752	5	93.8	11.2	13.2	
	4804	12	78.2	12.0	13.0	
	4808	16	67.7	13.0	12.2	
	4825	22	94.2	14.0	11.8	
	4841	17	56.7	12.8	13.2	
	4863	27	94.5	16.0	10.5	
	4952	20	42.5	19.2	7.8	
	5000	24	28.5	13.0	15.0	
	5072	23	56.7	14.0	14.0	
	5113	10	87.0	20.8	7.2	

Computations for latitude of Battle Mountain, Nev.

Date.	No. of pair.	Half-sum of declination.	Corrections. Micr. and refr.	Level.	Mord.	Latitude.
		° ′ ″	′ ″	″		° ′ ″
June 6, 1871	....	40 24 17.66	+13 58.11	+ 4.05	....	40 38 19.82
	....	21 47.85	+16 30.13	+ 3.85	....	21.83
	....	35 35.02	+ 2 36.42	+ 7.26	....	18.70
June 7, 1871	....	40 19 36.46	+18 36.24	+ 4.19	....	16.89
	....	29 34.96	+ 8 40.61	+ 3.64	....	19.21
	....	24 17.95	+13 56.25	+ 5.26	....	19.46
	....	21 48.09	+16 22.16	+ 4.86	....	15.11
	....	35 35.30	+ 2 34.57	+ 6.95	....	16.82
June 8, 1871	....	40 50 41.76	−12 22.92	+ 2.02	....	40 38 20.86
	....	42 56.26	− 4 39.54	+ 0.14	....	16.86
	....	26 24.30	+11 52.38	+ 0.54	....	17.22
	....	46 11.65	− 7 52.12	+ 0.34	....	19.19
	....	50 17.23	−11 59.50	+ 3.04	....	20.77
	....	41 54.87	− 3 42.07	+ 5.60	....	18.40
	....	45 18.28	− 7 4.31	+ 4.32	....	18.29
	....	46 42.34	− 8 23.70	+ 0.67	....	19.31
	....	19 36.73	+18 37.91	+ 0.47	....	15.11
	....	19 36.72	+18 42.71	0.00	....	19.43
	....	29 35.22	+ 8 42.78	+ 2.90	....	20.90
	....	24 18.20	+13 55.82	+ 3.78	....	17.80
	....	21 48.38	+16 27.55	+ 3.78	....	19.71
	....	35 35.57	+ 2 34.77	+ 6.01	....	16.35
	....	30 36.80	+ 7 36.54	+ 4.52	....	17.86
	....	38 15.72	− 0 7.68	+10.39	....	18.43
June 9, 1871	....	40 50 41.91	−12 18.29	− 4.59	....	18.93
	....	26 24.51	+12 4.34	− 9.18	....	19.67
	....	46 11.84	− 7 49.20	− 2.43	....	20.21
	....	50 17.41	−11 57.88	− 2.90	....	16.63
	....	40 58.28	− 2 37 51	− 0.14	....	20.63
	....	41 55.08	− 3 37.37	+ 1.21	....	18.92
	....	45 18.49	− 6 59.70	+ 3.44	....	22.23
	....	40 48.50	− 2 36.10	+ 6.34	....	18.74
	....	46 42.59	− 8 33.49	+ 9.18	....	18.28

Mean latitude of Battle Mountain, Nev , 40° 38′ 18″. 74 ±0″. 21.

Resulting astronomical co-ordinates.

Adopting the longitude of Detroit as given in the Report of the Chief of Engineers for 1871, to be—
0^h 24^m 0.14^s west of Washington, or
83° 3′ 3″. 90 west of Greenwich—
The resulting astronomical co-ordinates of Battle Mountain, Nev., will be—
Longitude: 116° 56′ 13″. 50 west of Greenwich.
39° 53′ 11″. 70 west of Washington.
Latitude: N. 40° 38′ 18″. 74 ±0″. 21.

AUSTIN, NEVADA.

Longitude 117° 03′ 41″.70; latitude 39° 29′ 21″.92.

The astronomical station is situated near Austin, Nev., in the cañon through which the road to Belmont passes. A short distance above the Manhattan Mill, to the east of the station, the land rises rapidly to Mount Prometheus; to the north, there is a slope downward to the valley of the Reese River. The mountains to the south and west rise to a height of several hundred feet above the station. The weather seems to have been quite fair when the station was occupied; at least, at night. During the day the clouds accumulated about 3 p. m., clearing again at 11 p. m. No detailed meteorological observations were made by the observer. The observations were taken in the same tent used at Carlin and Battle Mountain; the instrument was placed on three pieces of board buried three feet in the ground. The observer, E. P. Austin, was assisted by two soldiers.

The wires of the Western Union Telegraph Company were used for exchange of signals. For time and latitude observations the same instruments were used as at Carlin and Battle Mountain, a description of which is given in the proper place in the report on Carlin.

Connection was made with Washington and Detroit; Washington could be reached only once. The result derived from the exchanges between Austin, and Detroit and Washington for the longitude of Detroit is again larger than that given in the Report of the Chief of Engineers for 1871. This discrepancy of the results, being all independent of each other, will be investigated at another time.

The observations for time were taken on the 16th, 26th, and 29th of June; those for latitude on June 15, 17, 21, and 23. The corresponding determinations for time at Detroit were taken by Mr. O. B. Wheeler, assistant United States lake-survey, and at Washington by Prof. John R. Eastman, United States Naval Observatory. The reductions of the observations, made at the connected places, were made in the respective offices; those for Austin station by Dr. F. Kampf, who also prepared the report.

The explanation of signs in the report for the Detroit observations will be found in the report for Carlin; the same report contains the observations and computations for time relating to Washington.

For the reductions of observations made at Austin, the same instrumental values as given in the report on Carlin station were used. The signals were sent through by means of automatic repeaters; the number of them and also the places where they are situated are given in the Carlin report.

Computation of clock-correction for Detroit, June 16, 1871.

Ill.	Star.	C △ i	Aberr.	B b	C c	t	a	(a—t)	v
		s.	s.	s.	s.	h. m. s.	h. m. s.	m. s.	s.
W.	β Bootis	+ .04	− .02	+ .29	+ .08	14 58 32.36	14 57 06.78	−1 25.97	+ .16
	48 Cephei, L. C.	....	+ .06	− .47	− .29	15 05 25.12	3 03 58.79	25.63	......
	β Libræ	+ .03	− .01	+ .14	+ .07	11 30.94	15 10 05.49	25.68	− .15
	α Coronæ Borealis	+ .03	− .02	+ .23	+ .07	30 40.68	29 15.14	25.85	+ .01
	α Serpentis	+ .03	− .01	+ .19	+ .07	39 22.07	37 56.38	25.97	+ .12
	ε Serpentis	+ .03	− .01	+ .19	+ .06	45 50.31	44 24.75	25.83	− .03
	ζ Ursæ Minoris	+ .16	− .07	+ .97	+ .31	50 12.81	48 48.52	25.66	− .16
	ε Coronæ Borealis	+ .03	− .02	+ .28	+ .07	53 42.05	52 16.54	25.87	+ .01
W.	δ Ophiuchi	+ .03	− .01	+ .18	+ .06	16 09 02.44	16 07 36.79	25.91	+ .03
E.	ζ Ophiuchi	− .03	− .01	+ .12	− .07	31 30.68	30 05.11	25.58	− .32
	η Herculis	− .04	− .02	+ .24	− .08	39 56.30	38 30.35	26 05	+ .14
	κ Ophiuchi	− .03	− .01	+ .17	− .07	53 01.20	51 35.39	25.87	− .05
	ε Ursæ Minoris	....	− .10	+1.16	− .47	17 00 50.24	59 25.52	25.31	......
E.	a^1 Herculis	− .03	− .02	+ .18	− .07	10 13.51	17 08 47.64	25.93	.00
E.	κ Aquilæ	− .03	− .01	+ 06	− .07	19 31 24.57	19 29 58.59	25.93	− .01
	γ Aquilæ	− .03	− .01	+ .08	− .07	41 35.08	40 09.12	25.93	− .05
	α Aquilæ	− .03	− .01	+ .08	− .07	45 56.92	44 30.85	26.04	+ .07
	β Aquilæ	− .03	− .01	+ .07	− .07	50 26.10	49 00.06	26.00	+ .03
E.	λ Ursæ Minoris	....	− .74	+3.88	−3.39	19 55 44.83	54 13.55	31.03	......
W.	λ Ursæ Minoris	....	+ .74	+3.88	....	29.67	....	....	......
	a^2 Capricorni	+ .03	− .01	+ .06	+ .07	20 12 21.07	20 10 55.20	26.02	+ .08
W.	ε Delphini	+ .03	− .01	+ .09	+ .07	28 30.22	27 04.33	26.07	+ .06

Normal equations.

$$+\ 49.63\,a \qquad\qquad + \ 9.61\,\rho + \ 1.74\,\delta\theta + \ 3.60 = 0$$
$$+\ 1480.91\,a' + 90.89\,\rho - 34.62\,\delta\theta - 228.03 = 0$$
$$+\ 9.61\,a + \ 90.89\,a' + 77.44\,\rho \qquad - \ 16.81 = 0$$
$$+\ 1.74\,a - \ 34.62\,a' \qquad + 21.00\,\delta\theta + \ 23.13 = 0$$

$a = -\ 0^s.01$

$a' = +\ 0^s.14$

$c = -\ 0^s.06$ lamp east.

$\rho = +\ 0^s.051$, per hour.

$\Delta t = -\ 1^m\ 25^s.93 \pm 0^s.019$ at $17^h\ 19^m$

Computation of clock-correction for Detroit, June 26, 1871.

Ill.	Star.	C Δ i	Aberr.	B b	C c	t'	a	(a—t)	v
		s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s*	*s.*
E.	β Bootis	—.08	—.02	+ .15	— .10	14 58 35.55	14 57 06.66	—1 28.84	+.16
	48 Cephei, L. C	+.14	+.06	— .27	+ .35	15 05 28.01	15 03 59.68	28.61	......
	μ^1 Bootis	—.08	—.02	+ .18	— .10	21 07.49	19 38.63	28.84	+.17
	α Coronæ Borealis	—.07	—.02	+ .17	— .09	30 43.75	29 15.09	28.65	+.01
	α Scorpii	—.06	—.01	+ .13	— .08	39 24.93	37 56.37	28.54	+.06
	ε Serpentis	—.06	—.01	+ .14	— .08	45 53.16	44 24.74	28.41	—.19
	ε Coronæ Borealis	—.07	—.02	+ .20	— .09	53 45.14	52 16.50	28.66	+.04
	δ Ophiuchi	—.06	—.01	+ .14	— .08	16 09 05.23	16 07 36.81	28.41	—.16
	ζ Ophiuchi	—.06	—.01	+ .13	— .08	31 33.49	30 05.14	28.33	—.21
E.	κ Ophiuchi	—.06	—.01	+ .18	— .08	53 03.93	51 35.42	28.54	.00
W.	δ Ophiuchi	+.06	—.01	+ .15	+ .08	17 30 26.85	17 28 58.56	28.57	+.05
W.	ζ Aquilæ	+.06	—.01	+ .20	+ .08	19 00 58.79	18 59 30.57	28.55	+.11
	ω Aquilæ	+.06	—.01	+ .16	+ .08	13 15.69	19 11 47.40	28.58	+.14
	δ Aquilæ	+.06	—.01	+ .13	+ .08	20 29.48	19 01.35	28.39	—.02
	κ Aquilæ	+.06	—.01	+ .10	+ .08	31 26.91	29 58.78	28.36	—.02
W.	λ Ursæ Minoris	....	—.74	+4.78	+4.12	55 40.46	54 16.37	32.25	.00
E.	ε Delphini	—.06	—.01	+ .11	— .08	20 28 32.83	20 27 04.55	28.24	—.13
	α Cygni	—.08	—.02	+ .18	— .11	38 32.63	37 03.96	28.64	+.22
	μ Aquarii	—.06	—.01	+ .08	— .08	47 11.52	45 43.19	28.26	—.06
	32 Vulpeculæ	—.07	—.02	+ .12	— .09	50 33.70	49 05.35	28.29	—.06
	61^1 Cygni	—.08	—.02	+ .16	— .10	21 02 37.45	21 01 08.83	28.58	+.10
E.	ζ Cygni	—.07	—.02	+ .13	— .09	08 56.69	07 28.32	28.32	—.04

Normal equations.

$$+1502.25\,a + 83.30\,\rho - 25.67\,\delta\theta - 157.33 = 0$$
$$+ 83.30\,a + 111.16\,\rho \qquad - 2.30 = 0$$
$$- 25.67\,a \qquad + 22.00\,\delta\theta + 14.86 = 0$$

$a = + 0^s.10$

$c = - 0^s.08$, lamp east.

$\rho = - 0^s.053$, per hour.

$\Delta t = -1^m\ 28^s.54 \pm 0^s.010$, at $18^h\ 04^m$

Computation of clock-correction for Detroit, June 29, 1871.

No wires.	Ill.	Star.	C Δ i	Aberr.	B b	C c	t'	a	(a—t)	v
			s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*	*s.*
9	W.	β Ursæ Minoris	+.23	—.05	+ .68	+ .13	14 52 32.24	14 51 09.25	—1 23.98	......
9		β Bootis	+.08	—.02	+ .26	+ .04	58 30.83	57 06.62	24.57	+.08
9		β Libræ	+.06	—.01	+ .11	+ .04	15 11 29.59	15 10 05.45	24.34	+.13
5		μ^1 Bootis	+.04	—.02	+ .23	+ .04	21 02 77	19 38.60	24.46	.00
9		α Serpentis	+.06	—.01	+ .16	+ .04	39 20.55	37 56.36	24.44	+.01
9		ε Serpentis	+.06	—.01	+ .17	+ .04	45 48.84	44 24.73	24.27	—.15
5		ζ Ursæ Minoris	+.16	—.07	+ .88	+ .17	50 10.47	48 47.70	23.91	......
9		ε Coronæ Borealis	+.04	—.02	+ .25	+ .04	53 40.61	52 16.49	24.43	+.02
9		β^1 Scorpii	+.06	—.01	+ .12	+ .04	59 22.05	57 58.00	24.26	—.14
9		δ Ophiuchi	+.06	—.01	+ .17	+ .03	16 08 00.89	16 07 36.81	24.23	—.17
5		τ Herculis	+.05	—.02	+ .37	+ .05	17 17.83	15 53.64	24.64	+.26
9		ζ Ophiuchi	+.06	—.01	+ .15	+ .04	31 29.14	30 05.15	24.23	—.13
9		ζ Herculis	+.07	—.02	+ .29	+ .04	37 51.37	36 27.20	24.55	+.20
9		η Herculis	+.07	—.02	+ .29	+ .04	39 54.39	38 30.31	24.46	+.11
9		κ Ophiuchi	+.06	—.01	+ .22	+ .04	52 59.59	51 35.43	24.47	+.14
7	W.	ε Ursæ Minoris	......	—.10	+1.49	+ .25	17 00 46.86	59 24.69	23.81	......
5	E.	α^1 Herculis	+.03	—.01	+ .13	— .04	10 12.00	17 08 47.70	24.35	+.04
5		α Ophiuchi	+.03	—.01	+ .13	— .04	30 22.82	28 58.58	24.29	+.01
5		μ Herculis	+.04	—.02	+ .16	— .04	42 50.72	41 26.50	24.28	+.02
5		δ Ursæ Minoris	+.54	—.24	+1.79	— .57	18 15 41.00	18 14 16.93	24.51	......
5		κ Aquilæ	+.03	—.01	+ .12	— .04	19 31 22.83	19 29 58.83	24.04	—.07
5		γ Aquilæ	+.03	—.01	+ .13	— .04	41 33.41	40 09.36	24.10	.00
5		α Aquilæ	+.03	—.01	+ .10	— .04	45 55.05	44 31.09	23.98	—.12
3	E.	λ Ursæ Minoris	......	—.74	+1.79	—1.81	55 41.23	54 17.05	23.42	......

Normal equations.

$$+1361.89\,a + 125.63\,\rho - 51.00\,\delta\theta + 19.91 = 0$$
$$+125.63\,a + 55.18\,\rho + 4.89 = 0$$
$$-51.00\,a + 24.00\,\delta\theta + 6.02 = 0$$

$a = -0^s.003.$
$c = -0^s.03$, lamp east.
$\rho = -0^s.082$, per hour.
$\Delta t = -1^m\,24^s.33 \pm 0^s.019$, at $16^h\,53^m$.

Austin, Nev., June 16, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
η Bootis	E.	13 48 1.08	+0.22	+0.76	−0.36	13 48 1.70	13 48 33.64	+0 31.94
50 Cassiopeæ, L. C.	....	51 47.76	−0.25	+6.15	+1.08	51 54.74	52 26.28	31.54
α Draconis	....	14 0 26.42	+0.53	−2.11	−0.80	14 0 24.04	14 0 55.45	31.41
α Bootis	....	9 15.28	+0.29	+0.74	−0.36	9 15.95	9 47.80	31.85
ι Cassiopeæ, L. C.	W.	17 50.35	−0.12	+5.04	−0.86	17 54.41	18 26.44	32.03
θ Bootis	....	20 17.51	+0.28	−0.76	+0.56	20 17.59	20 49.86	32.27
5 Ursæ Minoris	....	27 24.62	+0.58	−5.20	+1.43	27 21.43	27 53.23	31.80
ε Bootis	....	38 49.72	+0.13	+0.48	+0.38	38 50.71	39 22.56	+0 31.85
Mean for $14^h\,30^m$ local sidereal time								+0 31.836

Normal equations.

$0 = +\ 0.08\ \ + 8.00\,\delta t\ - 2.47\,a'\ - 3.15\,c \qquad \delta t = -0^s.163$
$0 = +\ 1.00\ \ + 2.47\,\delta t\ + 22.68\,a'\ + 5.92\,c \qquad a' = +0^s.063$
$0 = +\ 14.82\ - 3.15\,\delta t\ + 5.99\,a'\ + 46.35\,c \qquad c = -0^s.339$

Adopted azimuth $= +2^s.00$; the whole azimuth of the instrument, $a = +2^s.063$.

Austin, Nev., June 16, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
θ Sagittarii	E.	19 9 31.40	−0.03	+4.44	−0.36	19 9 35.45	19 10 6.88	+0 31.43
δ Draconis	....	12 9.85	−0.15	−6.00	−0.89	12 2.81	12 34.46	31.65
δ Aquilæ	....	18 27.26	−0.06	+2.93	−0.34	18 29.79	19 1.17	31.38
κ Aquilæ	....	29 23.80	0.00	+3.56	−0.34	29 27.02	29 58.59	31.57
γ Aquilæ	....	39 35.78	+0.04	+2.39	−0.35	39 37.86	40 9.12	31.26
α Aquilæ	....	43 57.38	+0.06	+2.54	−0.35	43 59.63	44 30.85	31.22
ε Draconis	....	48 15.98	+0.25	−7.22	−0.99	48 8.02	48 39.22	+0 31.20
Mean for $19^h\,30^m$ local sidereal time								+0 31.387

Normal equations.

$0 = -\ 0.55\ \ + 7.00\,\delta t\ + 0.54\,a' \qquad \delta t = +0^s.08$
$0 = +\ 0.68\ \ + 0.54\,\delta t\ + 5.93\,a' \qquad a' = -0^s.122$

Adopted azimuth, $+5^s.00$; whole azimuth, $+4^s.878$.

Austin, Nev., June 26, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
α Draconis	W.	14 0 9.75	+0.91	+13.11	+1.35	14 0 25.12	14 0 55.45	+0 30.33
κ Virginis	....	5 42.48	+0.25	− 9.89	+0.58	5 33.42	6 2.09	28.67
α Bootis	....	9 22.60	+0.30	− 4.60	+0.61	9 18.91	9 47.72	28.81
θ Bootis	....	20 14.20	+0.58	+ 4.74	+0.93	20 20.45	20 49.67	29.22
5 Ursæ Minoris	....	26 47.28	+0.95	+ 2.44	+2.41	27 23.08	27 52.54	29.46
ε Bootis	....	38 55.40	+0.29	−32.98	+0.64	38 53.35	39 22.48	29.13
α^2 Libræ	E.	43 27.50	+0.11	−10.93	−0.59	43 16.09	43 46.04	29.95
β Ursæ Minoris	....	50 13.66	+0.68	+28.08	−2 16	50 40.26	51 9.44	29.18
β Bootis	....	56 36.80	+0.46	+ 0.49	−0.37	56 36.88	57 6.68	29.80
β Libræ	....	15 9 45.84	+0.06	−10.13	−0.56	15 9 35.21	15 10 5.46	30.25
μ^1 Bootis	....	19 9.85	+0.11	− 0.48	−0.72	19 8.76	19 38.19	+0 29.43
Mean for $14^h\,40^m$ local sidereal time								+0 29.475

Normal equations.

$$0 = -4.68 + 11.00\,\delta t - 3.09\,a - 2.80\,c \qquad \delta t = -0^s.525$$
$$0 = +42.80 - 3.09\,\delta t + 14.42\,a + 5.64\,c \qquad a = -2^s.858$$
$$0 = +43.17 - 2.80\,\delta t + 5.64\,a + 49.98\,c \qquad c = +0^s.570$$

Adopted azimuth, $-10^s.00$; whole azimuth of the instrument, $-12^s.858$.

Austin, Nev., June 29, 1871.

Name of star.	Clamp.	T	b B	a A	c C	T	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
5 Ursæ Minoris..	E.	14 27 40.83	−0.41	−10.64	−1.11	14 27 28.67	14 27 52.32	+0 23.65
π Bootis........	....	34 16.22	−0.20	+ 1.83	−0.28	34 17.57	34 41.00	23.43
ϵ Bootis........	....	38 58.40	−0.31	+ 1.05	−0.30	38 58.84	39 22.04	23.20
α^2 Libræ........	....	43 19.20	−0.20	+ 3.90	−0.27	43 22.63	43 46.02	23.39
β Ursæ Minoris..	....	50 57.06	−0.16	−10.00	−1.00	50 45.90	51 9.25	23.35
β Bootis........	....	56 43.98	−0.20	− 0.18	−0.40	56 43.20	57 6.62	23.42
48 Cephei, L. C....	W.	15 3 18.96	+0.43	+18.57	−1.19	15 3 36.77	15 3 59.96	23.19
β Libræ........	....	9 38.22	−0.22	+ 3.62	+0.27	9 41.89	10 5.45	23.56
γ^2 Ursæ Minoris..	....	20 45.32	−0.86	− 8.16	+0.87	20 37.17	21 0.04	22.87
α Coronæ........	....	28 50.50	−0.35	+ 1.10	+0.29	28 51.54	29 15.07	23.53
α Serpentis........	....	37 30.08	−0.34	+ 2.48	+0.27	37 32.49	37 56.36	+0 23.87
Mean for $15^h\ 0^m$ local sidereal time								+0 23.405

Normal equations.

$$0 = +1.48 + 11.00\,\delta t + 0.78\,a + 10.86\,c$$
$$0 = -13.57 + 0.78\,\delta t + 31.61\,a + 2.91\,c \qquad a = -0^s.415$$
$$0 = -15.71 + 10.86\,\delta t + 2.91\,a + 72.60\,c \qquad c = -0^s.263$$

Adopted azimuth, $+5^s.00$: whole azimuth of the instrument, $+4^s.585$.

The following table shows the corrections and rates for the sidereal chronometer:

Negus 1344.

Date.	Local sidereal time.	Correction of chronometer.	Adopted hourly rate.
	h.	*m. s.*	*s.*
June 16, 1871	17.0	+0 31.612	+0.042
June 26, 1871	14.7	+0 29.475	+0.070
June 29, 1871	15.0	+0 23.405	+0.085

The signals were sent by sound from the mean-time chronometer Hutton No. 288. It was compared with Negus 1344, both before and after exchange. The comparison, June 16, 1871, made before exchange, is:

	h.	*m.*	*s.*	*h.*	*m.*	*s.*
Negus 1344................	14	45	45.0	14	48	50.0
Hutton 288................	8	45	37.0	8	48	41.5

and after exchange—

	h.	*m.*	*s.*	*h.*	*m.*	*s.*
Negus 1344................	18	44	16.0	18	47	20.0
Hutton 288................	12	43	37.0	12	46	40.5

The hourly rate of Hutton 288, derived from these comparisons, would be $7^s.773$; this first comparison has to be rejected, as there is evidently a mistake in it, as shown by the comparison below. Both chronometers were compared again the next morning.

	h.	*m.*	*s.*
Negus 1344................	6	44	37.0
Hutton 288................	0	41	59.5

The rate derived from this comparison and that made after exchange is $9^s.8561$, and is used for the determination of the change of Hutton 288 against sidereal time.

Exchange of signals between Detroit, Mich., and Battle Mountain, Nev.

JUNE 1, 1871.—*Signals sent from Detroit.*

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
17	22	40.25	10	3	49.80				10	5	......	17	26	20.05	10	7	29.00
		50.06			50.60	17	24	40.10			49.30			30.20			39.00
	23	0.35		4	9.80			50.20			59.10			40.20			49.00
							25	0.24		6	9.40			50.15			59.00
	24	0.21		5	9.80								27	0.21		8	9.00
		10.03			19.20		26	0.25		7	9.30						
		20.05			29.20			10.19			19.00	Mean, 17	25	3.92	10	6	13.03

SECOND SERIES.

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
17	52	40.29	10	33	44.80	17	54	50.10	10	35	54.40	17	57	0.05	10	38	4.00
		50.21			54.70		55	0.08		36	4.30			10.05			14.00
	53	0.21		34	4.60			10.18			14.30			20.10			23.90
		10.20			14.50			20.10			24.00			30.20			33.90
		20.15			24.50			30.20			34.10			40.10			44.00
		30.20			34.50			40.20			44.20						
		40.11			44.50							Mean, 17	55	10.14	10	36	14.26
							56	40.05		37	43.90						
	54	40.08		35	44.30			50.14			54.00						

Signals sent from Battle Mountain.

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
17	40	24.31	10	22	10.00	17	44	54.92	10	26	40.00	17	46	15.10	10	28	0.00
		29.50			15.00			59.95			45.00			20.05			5.00
		34.22			20.00		45	4.90			50.00			25.12			10.00
		39.31			25.00			9.92			55.00			30.25			15.00
		44.28			30.00			14.91		27	0.00			35.20			20.00
		49.45			35.00			19.90			5.00			40.50			25.00
		54.60			40.00			24.98			10.00			45.35			30.00
								30.10			15.00			50.30			35.00
	41	14.88		26	0.00			35.15			20.00			55.31			40.00
		19.69			5.00			40.40			25.00		47	0.20			45.00
		24.80			10.00			45.10			30.00			5.19			50.00
		29.90			15.00			50.27			25.00			10.30			55.00
		34.88			20.00			55.06			40.00			15.20		29	0.00
		39.92			25.00		46	0.20			45.00						
		45.00			30.00			5.18			50.00	Mean, 17	44	56.44	10	26	41.48
		49.75			35.00			10.06			55.00						

JUNE 3, 1871.—*Signals sent from Detroit.*

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
16	41	......	9	14	......	16	43	10.12	9	16	28.80	16	45	20.05	9	18	38.40
		10.25			29.10			20.08			38.60			30.25			48.50
		20.00			39.00			30.10			48.60			40.12			58.50
		30.15			49.10			40.20			58.70			50.12		19	8.30
		40.25			59.10			50.29		17	8.60		46	0.40			18.50
		50.37		15	9.20		44	0.30			18.80						
	42	0.25			19.00							Mean, 16	43	37.70	9	16	56.24
							45	0.28		18	18.60						
	43	0.38		16	19.00			10.08			28.40						

SECOND SERIES.

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
17	0	0.25	9	31	16.50
		10.05			26.10
		20.13			36.20
		30.21			46.30
		40.11			56.00
		50.23		32	6.00
	1	0.41			16.00
	2	0.30		33	15.90

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
17	2	10.20	9	33	25.80
		20.18			35.80
		30.15			45.80
		40.21			55.80
		50.13		34	6.00
	3	0.18			16.00
	4	0.10		35	15.40
		10.20			25.50

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
17	4	20.20	9	35	35.40
					......
		40.18			55.50
		50.25		36	5.40
	5	0.20			15.20
Mean, 17	2	24.19	9	33	39.83

Signals sent from Battle Mountain.

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
16	49	43.23	9	23	0.00
		48.30			5.00
		53.12			10.00
		58.20			15.00
	50	3.30			20.00
		8.83			25.00
		13.50			30.00
		18.61			35.00
		23.68			40.00
		28.68			45.00
		33.45			50.00
		38.60			55.00
		43.42		24	0.00
		48.41			5.00
		53.45			10.00
		58.55			15.00
	51	3.50			20.00
		8.82			25.00
		13.60			30.00
		18.70			35.00
		23.70			40.00

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
16	51	28.72	9	24	45.00
		33.45			50.00
		38.60			55.00
		43.70		25	0.00
		48.70			5.00
		53.59			10.00
		58.59			15.00
	52	3.85			20.00
		8.83			25.00
		13.81			30.00
		18.89			35.00
		23.78			40.00
		28.71			45.00
		33.74			50.00
		38.59			55.00
		43.60		26	0.00
		48.68			5.00
		53.70			10.00
		58.75			15.00
	53	3.71			20.00
		8.95			25.00

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
16	53	13.93	9	26	30.00
		19.05			35.00
		23.88			40.00
		28.80			45.00
		33.90			50.00
		38.85			55.00
		43.82		27	0.00
		48.90			5.00
		53.80			10.00
		59.10			15.00
	54	4.10			20.00
		9.34			25.00
		14.10			30.00
		19.20			35.00
		24.36			40.00
		29.20			45.00
		34.08			50.00
		39.15			55.00
		44.00		28	0.00
Mean, 16	52	13.75	9	25	30.00

JUNE 10, 1871.—*Signals sent from Detroit.*

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
17	12	......	9	17	......
		10.10			45.10
		20.25			55.40
		30.20		18	5.40
		40.45			15.50
		50.20			25.10
	13	0.20			35.10
	14	0.25		19	35.10

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
17	14	10.00	9	19	44.80
		20.15			54.90
		30.10		20	4.90
		40.10			14.90
		50.20			24.80
	15	0.10			34.60
	16	0.43		21	34.60
		10.10			44.40

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
17	16	20.10	9	21	54.60
		30.10		22	4.50
		40.10			14.40
		50.15			24.20
	17	0.55			34.10
Mean, 17	14	37.69	9	20	12.32

SECOND SERIES.

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
17	26	30.24	9	32	3.00
		40.00			12.70
		50.20			22.70
	27	0.20			32.70
		10.10			42.60
		20.12			52.50
		30.10		33	2.60
	28	30.27		34	2.60

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
17	28	40.21	9	34	12.60
		50.21			22.50
		59.84			32.20
	29	10.12			42.40
		20.15			52.40
		30.21		35	2.40
	30	30.21		36	2.20
		40.18			12.20

Detroit clock.			Battle Mountain chronometer.		
h.	m.	s.	h.	m.	s.
17	30	50.15	9	36	22.00
	31	0.00			32.00
		10.26			42.10
		20.10			52.00
		30.30		37	2.10
Mean, 17	29	0.15	9	34	32.40

Signals sent from Battle Mountain.

Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.			Detroit clock.			Battle Mountain chronometer.		
h.	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
17	19	26.69	9	25	0.00	17	21	6.93	9	26	40.00	17	22	47.29	9	28	20.00
		31.75			5.00			12.08			45.00			52.38			25.00
		36.60			10.00			17.90			50.00			57.30			30.00
		41.89			15.00			21.86			55.00		23	2.46			35.00
		46.90			20.00			27.03		27	0.00			7.42			40.00
		51.84			25.00			32.01			5.00			12.49			45.00
		56.88			30.00			36.82			10.00			17.45			50.00
	20	1.92			35.00			41.90			15.00			22.50			55.00
		7.15			40.00			47.18			20.00			27.55		29	0.00
		12.10			45.00			51.92			25.00			32.41			5.00
		17.03			50.00			57.25			30.00			37.48			10.00
		22.00			55.00		22	2.15			35.00			42.40			15.00
		26.90		26	0.00			7.24			40.00			47.62			20.00
		32.00			5.00			12.45			45.00			52.55			25.00
		37.00			10.00			17.25			50.00			57.50			30.00
		41.96			15.00			22.50			55.00		24	2.72			35.00
		46.95			20.00			27.35		28	0.00						
		51.95			25.00			32.35			5.00	Mean, 17	21	44.66	9	27	17.50
		56.98			30.00			37.32			10.00						
	21	2.00			35.00			42.30			15.00						

Deduction of the results for longitude.

Date.	Signals sent from—	Detroit clock.	Clock correction.	Local sidereal time of the mean of the signals.	Battle Mountain chronometer.	Correction of chronometer.	Local sidereal time of the mean of the signals.	Differences of longitude.	Mean.	Double-wave time.	Final differences of longitude.
		h. m. s.	m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	s.	s.	h. m. s.
June 1, 1871	Detroit to Battle Mountain.	17 25 3.92	−1 8.91	17 23 55.01	10 6 13.03	+5 2 9.65	15 8 22.68	2 15 32.33	......	.....	....
June 1, 1871	Detroit to Battle Mountain.	17 55 10.14	1 8.94	17 54 1.20	10 36 14.26	2 14.60	15 38 28.86	32.34	32.34	.....	....
June 1, 1871	Battle Mountain to Detroit.	17 44 56.44	1 8.92	17 43 47.52	16 26 41.48	2 13.02	15 28 54.50	33.02	33.02	0.68	2 15 32.68
June 3, 1871	Detroit to Battle Mountain.	16 43 37.70	−1 13.64	16 42 24.06	9 16 56.24	+5 9 55.45	14 26 51.69	32.37	......	.....	....
June 3, 1871	Detroit to Battle Mountain.	17 2 24.19	1 13.69	17 1 10.50	9 33 39.83	9 58.30	14 43 38.13	32.37	32.37	.....	....
June 3, 1871	Battle Mountain to Detroit.	16 52 13.75	1 13.67	16 51 0.08	9 25 30.00	9 56.91	14 35 26.91	33.17	33.17	0.80	32.77
June 10, 1871	Detroit to Battle Mountain.	17 14 37.69	−1 21.34	17 13 16.35	9 20 12.32	+5 37 31.87	14 57 44.19	32.16	......	.....	....
June 10, 1871	Detroit to Battle Mountain.	17 29 0.15	1 21.35	17 27 38.80	9 34 32.40	37 34.24	15 12 6.64	32.16	32.16	.....	....
June 10, 1871	Battle Mountain to Detroit.	17 21 44.66	1 21.34	17 20 23.32	9 27 17.50	37 33.04	15 4 50.54	32.78	32.78	0.62	32.47

Battle Mountain west of Detroit $2^h\ 15^m\ 32^s.64 \pm 0^s.06$.

SECOND SERIES.

Detroit clock.	Austin chronometer.	Detroit clock.	Austin chronometer.	Detroit clock.	Austin chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
19 10 0.38	10 0 31.6	19 12 10.26	10 2 41.0	19 16 20.21	10 6 50.5
10.32	41.5	20.17	51.1	30.30	7 0.6
20.12	51.6	30.20	3 1.0	40.20	10.5
30.23	1 1.6	40.21	11.0	50.00	20.4
40.16	11.5	50.22	21.1	17 0.32	30.5
50.25	21.6	13 0.18	31.1		
11 0.27	31.5			Mean, 19 13 10.23	10 3 41.06
		16 0.28	6 30.7		
12 0.27	2 31.3	10.20	40.5		

Signals sent from Austin.

Detroit clock.	Austin chronometer.	Detroit clock.	Austin chronometer.	Detroit clock.	Austin chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
19 1 27.99	9 52 0.00	19 3 13.13	9 53 45.00	19 4 58.43	9 55 30.00
32.98	5.00	18.27	50.00	5 3.47	35.00
37.83	10.00	23.32	55.00	8.42	40.00
43.00	15.00	28.46	54 0.00	13.55	45.00
48.18	20.00	33.37	5.00	18.67	50.00
53.00	25.00	38.29	10.00	23.63	55.00
58.10	30.00	43.26	15.00	28.77	56 0.00
2 2.93	35.00	48.27	20.00	33.76	5.00
8.00	40.00	53.25	25.00	38.48	10.00
13.00	45.00	58.42	30.00	43.70	15.00
18.16	50.00	4 3.52	35.00	48.79	20.00
23.10	55.00	8.45	40.00	53.64	25.00
28.00	53 0.00	13.46	45.00	58.72	30.00
33.23	5.00	18.45	50.00	6 3.80	35.00
38.00	10.00	23.35	55.00	8.85	40.00
43.00	15.00	28.65	55 0.00	13.79	45.00
48.00	20.00	33.66	5.00	18.73	50.00
53.10	25.00	38.41	10.00	23.83	55.00
58.22	30.00	43.35	15.00	28.84	57 0.00
3 3.26	35.00	48.45	20.00		
8.24	40.00	53.58	25.00	Mean, 19 3 58.37	9 51 30.00

Deduction of results for longitude of Austin, Nev.

Date.	Signals sent from—	Detroit clock.	Correction of Detroit clock.	Local sidereal time of the mean of signals.	Austin chronometer.	Correction of Austin chronometer.	Local sidereal time of the mean of signals.	Differences of longitude.	Means.	Double-wave time.	Final differences of longitude.
1871.		*h. m. s.*	*m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*s.*	*s.*	*h. m. s.*
June 16	Detroit to Austin	18 57 48.53	−1 26.01	18 56 22.52	10 39 30.36	+6 0 50.15	16 40 20.41	2 16 2.11			
16	Detroit to Austin	19 15 30.12	26.02	19 14 4.10	10 57 8.90	53.05	16 58 1.95	2.15	2.13		
16	Austin to Detroit	19 7 50.78	26.01	19 6 24.77	10 49 30.00	51.79	16 50 21.79	2.98	2.98	0.85	2 16 2.55
26	Detroit to Austin	19 48 39.04	−1 28.45	19 47 10.59	10 50 47.57	+6 40 20.98	17 31 8.55	2.04			
26	Detroit to Austin	20 10 30.11	28.43	20 9 1.68	11 12 35.09	24.60	17 52 59.69	1.99	2.01		
26	Austin to Detroit	20 3 30.63	28.43	20 2 2.20	11 5 35.69	23.44	17 45 59.13	3.07	3.07	1.06	2.54
29	Detroit to Austin	18 56 30.19	−1 24.17	18 55 6.02	9 47 3.78	+6 52 0.14	16 39 3.92	2.10			
29	Detroit to Austin	19 13 10.23	24.14	19 11 46.09	10 3 41.06	2.89	16 55 43.95	2.14	2.12		
29	Austin to Detroit	19 3 58.37	24.16	19 2 34.21	9 54 30.00	1.37	16 46 31.37	2.84	2.84	0.72	2.48

Austin west of Detroit, $2^h\ 16^m\ 2^s.52 \pm 0^s.015$.

Determination of longitude between Washington, D. C., and Austin, Nev.

June 16, 1871.	Mean of signals sent and received.	Time correction.	Corrected time.	Difference of longitude.	Means.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
Washington clock	20 16 0.00	−0 0 2.27	20 15 57.73	....	....
Austin chronometer	11 34 56.16	+6 0 59.26	17 35 55.42	2 40 2.31	....
Washington clock	20 38 15.40	−0 0 2.28	20 38 13.12	....	....
Austin chronometer	11 57 7.90	+6 1 2.90	17 58 10.80	2 40 2.32	2 40 2.32
Austin chronometer	11 44 12.74	+6 1 0.78	17 45 13.52	....	....
Washington clock	20 25 19.37	−0 0 2.28	20 25 17.09	2 40 3.57	....
Austin chronometer	12 7 50.00	+6 1 4.65	18 8 54.65	....	....
Washington clock	20 49 0.41	−0 0 2.28	20 48 58.13	2 40 3.48	....
Austin chronometer	12 17 45.50	+6 1 6.29	18 18 51.79	....	....
Washington clock	20 58 57.63	−0 0 2.28	20 58 55.35	2 40 3.56	2 40 3.54

Austin, Nev., west of Washington, D. C., 2*h.* 40*m.* 2.93*s.*

Mean places of stars for 1871 *used for determination of latitude of Austin, Nev.*

No. of pair.	No. in B. A. C.	Declination.	No. of pair.	No. in B. A. C.	Declination.
		° ′ ″			° ′ ″
	4847	16 58 22.31		5693	31 55 0.47
1	4874	61 48 45.81	11	5706	46 44 55.94
	4905	19 38 14.45	12	5740	65 19 54.64
2	4918	59 49 7.80	13	5745	65 14 7.35
				5753	13 47 26.25
	4980	48 39 1.13		5757	13 45 18.36
3	5001	29 43 14.44			
				5785	54 38 26.40
	5075	30 45 18.71	14	5798	24 23 49.00
4	5113	48 9 26.29			
				5863	32 38 9.99
	5259	36 3 33.20	15	5871	46 22 6.04
5	5271	42 48 48.95			
				5900	20 11 30.49
	5319	33 41 43.38	16	5918	58 45 37.83
6	5388	45 16 26.88			
				5951	55 15 38.97
	5426	19 8 8.60	17	5967	24 23 18.74
7	5459	60 4 6.27			
				6021	27 47 52.65
	5480	34 0 16.80	18	6052	50 48 45.30
8	5497	44 59 9.56			
				6087	30 12 5.28
	5568	46 52 31.27	19	6129	48 27 33.22
9	5604	31 50 17.80			
				6162	43 26 50.67
	5628	64 50 1.62	20	6235	36 0 27.75
10	5647	13 29 20.80			

Observations for latitude.—Station, Austin, Nev.

JUNE 15, 1871.

No. of star.	Micrometer-readings.	Level.		Remarks.
		N.	S.	
	t. d.	d.	d.	
4847	12 9.1	14.0	11.8	
4874	20 61.6	12.2	13.6	
4905	26 80.8	14.0	12.0	
4918	5 12.5	13.2	12.5	
5075	16 41.2	13.3	13.0	
5113	19 25.6	12.5	13.8	
5319	13 80.2	13.8	13.0	
5388	14 21.0	12.0	15.0	
5426	25 88.2	10.5	16.8	
5459	15 76.7	15.0	12.0	
5480	19 95.0	13.3	14.2	
5497	19 36.2	12.2	15.4	
5568	24 99.9	12.5	15.7	
5604	13 19.5	14.0	14.4	
5628	34 57.9	11.8	16.8	
5647	5 50.3	16.0	12.5	
5693	8 75.0	14.5	13.8	
5706	22 49.2	18.8	9.3	

No. of star.	Micrometer-readings.	Level.		Remarks.
		N.	S.	
	t. d.	d.	d.	
5740	12 18.2			
5745	16 48.1	16.8	11.0	
5753	18 48.5			
5757	16 93.4	6.5	21.5	
5785	12 69.7	15.8	12.5	
5798	15 38.0	11.5	16.5	
5863	18 41.1	12.8	15.7	
5871	17 27.4	14.2	14.0	
5900	20 10.6	13.0	15.0	
5918	21 22.4	14.5	14.0	
6021	11 19.6	13.5	15.0	
6052	27 67.7	13.0	15.6	
6087	15 27.5	14.0	14.8	
6129	29 49.6	11.2	17.2	
6162	7 45.0	12.5	16.2	
6235	28 60.0	16.5	12.8	

JUNE 17, 1871.

No. of star.	Micrometer-readings.	Level.		Remarks.
		N.	S.	
	t. d.	d.	d.	
4905	26 3.7	14.0	12.0	
4918	4 77.6	9.0	17.0	
4980	33 38.7	13.8	12.8	
5001	6 60.6	15.3	10.8	
5075	16 98.4	2.0	25.0	Must be $68^{d}.4$.
5113	19 51.5	22.0	5.2	
5319	13 63.6	13.0	15.8	
5388	14 7.8	12.0	17.2	
5426	26 81.0	15.2	12.8	
5459	16 71.8	11.5	17.8	
5480	20 15.2	13.8	16.0	
5497	19 59.5	13.7	15.6	
5568	24 22.3	15.5	14.2	Must be $2^{d}.3$.
5604	12 27.9	16.0	14.0	Excl.
5628	34 42.7	8.5	21.2	
5647	5 15.5	20.2	9.3	

No. of star.	Micrometer-readings.	Level.		Remarks.
		N.	S.	
	t. d.	d.	d.	
5740	11 61.0			
5745	15 92.5	13.0	16.9	
5753	18 10.2			
5757	16 56.3	16.5	13.5	
5785	13 36.7	14.0	15.8	
5798	15 94.4	13.7	16.3	
5863	19 39.4	17.0	12.8	
5871	18 30.0	12.3	17.2	
5900	21 13.8	15.8	14.8	
5918	22 31.6	11.8	17.8	
6021	11 41.3	11.2	17.2	
6052	27 84.8	15.8	12.8	
6087	14 61.7	13.0	15.0	
6129	28 57.9	11.2	16.2	
6162	6 89.4	12.2	14.6	
6235	27 92.7	9.8	16.5	

Observations for latitude.—Station, Austin, Nev.—Continued.

JUNE 21, 1871.

No. of star.	Microme-ter-read-ings.	Level. N.	Level. S.	Remarks.	No. of star.	Microme-ter-read-ings.	Level. N.	Level. S.	Remarks.
	t. d.	d.	d.			t. d.	d.	d.	
5568	24 75.3	14.8	17.8		5863	18 91.4	16.0	17.2	
5604	17 97.6	17.2	15.5	Must be 12^t.	5871	17 81.9	14.9	18.5	
5628	34 59.7	11.7	21.2		5900	22 20.0	16.4	17.0	
5647	5 40.2	21.2	11.5		5918	23 35.9	14.7	18.7	
5693	9 37.0	16.8	16.0		5951	4 81.0	17.0	16.5	
5706	23 29.1	15.0	17.7		5967	34 71.4	16.8	17.0	
5740	12 83.3	14.7	18.0		6021	11 34.5	17.5	16.1	
5745	17 2.9				6052	27 75.1	14.0	19.6	
5753	19 27.4	18.1	15.0						
5757	17 69.7				6087	14 63.7	17.5	16.3	
					6129	28 78.7	15.9	18.0	
5785	13 51.2	15.7	17.2						
5798	16 21.3	16.2	17.0		6162	7 73.0	15.9	18.1	
					6235	28 95.0	19.8	14.0	

JUNE 23, 1871.

No. of star.	Microme-ter-read-ings.	Level. N.	Level. S.	Remarks.	No. of star.	Microme-ter-read-ings.	Level. N.	Level. S.	Remarks.
	t. d.	d.	d.			t. d.	d.	d.	
5259	16 5.5	15.5	16.0		5480	20 86.2	20.8	12.5	
5271	20 65.4	15.2	17.0		5497	20 33.4	8.8	24.5	
5319	13 86.7	14.5	18.0		5568	25 29.5	16.5	17.0	
5388	14 31.9	14.2	19.0		5604	13 47.9	12.0	21.0	
5426	26 49.9	12.8	20.5		5628	34 25.0	13.8	19.5	
5459	16 45.5	17.5	15.5		5647	5 4.1	14.5	18.8	

Computations for latitude of Austin, Nev.

Date.	No. of pair.	Half-sum of declination.	Corrections. Micr. and refr.	Corrections. Level.	Corrections. Merid.	Latitude.
		° ′ ″	′ ″	″		° ′ ″
June 15, 1871	1	39 23 40.78	+ 5 44.77	+0.54	....	39 29 26.09
	2	43 47.75	−14 36.93	+1.82	....	22.64
	4	27 28.27	+ 1 55.01	−0.67	....	22.61
	6	29 9.43	+ 0 16.50	−1.48	....	24.45
	7	36 10.96	− 6 49.06	−2.23	....	19.67
	8	29 46.70	− 0 23.78	−2.77	....	20.15
	9	21 27.37	+ 7 57.37	−2.43	....	22.31
	10	9 43.52	+19 35.97	−1.01	....	20.48
	11	20 0.40	+ 9 15.75	+6.88	....	23.03
	12	33 42.18	− 4 14.91	−6.21	....	18.94
	13	29 44.56	− 0 18.31	−6.21	....	20.04
	14	31 9.20	− 1 48.50	−1.15	....	19.55
	15	30 8.97	− 0 45.98	−1.82	....	21.17
	16	28 34.74	+ 0 45.22	−1.01	....	18.95
	18	18 18.66	+11 6.53	−2.77	....	22.42
	19	19 48.31	+ 9 35.12	−4.59	....	18.84
	20	43 37.46	−14 15.35	0.00	....	22.11

Computations for latitude of Austin, Nev.—Continued.

Date.	No. of pair.	Half-sum of declination.	Corrections. Micr. and refr.	Level.	Merid.	Latitude.
		° ′ ″	′ ″	″		° ′ ″
June 17, 1871	2	39 43 48.10	−14 19.87	−4.05	....	39 29 24.18
	3	11 14.51	+18 3.10	+3.71	....	21.32
	4	27 28.70	+ 1 54.48	−2.16	....	21.02
	6	29 9.90	+ 0 17.87	−5.40	....	22.37
	7	36 11.43	− 6 48.13	−2.63	....	20.67
	8	29 47.20	− 0 22.53	−2.77	....	21.90
	10	9 43.99	+19 43.90	−1.21	....	26.68
	12	33 42.60	− 4 22.55	−0.61	....	19.44
	13	29 44.98	− 0 25.79	−0.61	....	18.58
	14	31 9.73	− 1 44.22	−2.97	....	22.54
	15	30 9.53	− 0 44.24	−0.47	....	24.82
	16	28 35.28	+ 0 47.65	−3.38	....	22.55
	18	18 19.22	+11 4.67	−2.02	....	21.87
	19	19 48.90	+ 9 36 78	−4.72	....	20.96
	20	43 38.14	−14 10.62	−6.14	....	21.38
June 21, 1871	9	39 21 28.92	+ 7 56.27	−0.88	....	39 29 24.31
	10	9 44.91	+19 40.78	+0.14	....	25.83
	11	20 2.10	+ 9 22.99	−1.28	....	23.81
	12	33 43.72	− 4 20.49	−0.14	....	23.09
	13	29 46.02	− 0 27.01	−0.13	....	18.88
	14	31 10.80	− 1 49.23	−1.55	....	20.02
	15	30 10.64	− 0 44.28	−3.24	....	26.12
	16	28 36.34	+ 0 46.88	−3.10	....	20.12
	17	49 30.82	−20 9.42	+0.20	....	21.60
	18	18 20.36	+11 3.49	−2.83	....	21.02
	19	19 50.06	+ 9 32.25	−0.61	....	21.70
	20	43 39.50	−14 18.18	+2.43	....	23.77
June 23, 1871	5	39 26 17.51	+ 3 5.99	+1.55	....	39 29 21.95
	6	29 11.32	+ 0 18.27	+5.60	....	23.99
	7	36 12.79	− 6 46.19	+3.85	....	22.75
	8	29 48.69	− 0 21.36	+4.99	....	22.34
	9	21 29.43	+ 7 57.85	+6.41	....	20.87
	10	9 45.38	+19 41.35	+6.75	....	19.98

Mean latitude of Austin, Nev., 39° 29′ 21″.92 ±0″.20

Adopting for the longitude of Detroit 83° 3′ 3″.90 west of Greenwich, the resulting astronomical co-ordinates of Austin, Nev., will be:

Longitude, 117° 3′ 41″.70 west of Greenwich.
40° 0′ 39″.90 west of Washington.
Latitude, N., 39° 29′ 21″.92 ±0″.20.

ST. GEORGE, UTAH.

Longitude, 113° 35′ 0″.30; latitude, 37° 06′ 29″ 38 ± 0″.08.

The astronomical station is situated in St. George, a Mormon town in Southwestern Utah, of about 2,000 inhabitants. The monument, a sandstone pier buried in the ground and 24 inches above the surface, is located 30 feet distant from the southern door of the school-house, 72 feet distant from the street running from east to west, and 150 feet from Main street. The connection with natural objects was made in the year 1872 by Mr. Thompson, topographer of the expedition of that year. The town is situated in the valley or cañon of the Virgin River, near the junction of the Santa Clara with this stream. To the westward, fifteen miles distant, is the Virgin range; to the north, the high Pine Valley range; while, to the south and east the broken, eroded, and faulted plateaus of the Colorado extend. In the immediate neighborhood are several smaller settlements, the most promising of which is Washington. The climate is mild, and the principal industry fruit and wine growing.

No detailed meteorological observations were taken at this place

when the station was occupied by the astronomer. As far as can be learned from the diary, the nights were pretty clear, and the condition of the air very favorable for astronomical observations. In 1872 some barometric observations were taken to determine the altitude of the place.

The astronomical observations were taken in a common wall-tent, as at the other stations. Mr. A. R. Marvine, the observer, was assisted by a recorder and two soldiers, and Mr. E. P. Austin had charge of the Salt Lake observatory, the use of which was kindly tendered by President Brigham Young, of the Mormon church. Through him the use of the Deseret Telegraph line, for exchange of signals, was secured. The wires were brought into the tent by a loop.

The astronomical instruments used at St. George were the combined transit, used before by Assistant E. P. Austin, in Nevada, and the sidereal chronometer, Negus No. 1344. The Salt Lake instrument belonged to President Young, and was used by a Coast-Survey party, and by the expeditions of 1872 and 1873. All the data relating to this instrument will be found in the general report for 1873 by J. H. Clark.

Hutton mean-time chronometer No. 288 was used for the determination of time. All the observations were taken by eye and ear, and the exchange of signals made by sound.

Connection was made, as stated, with Salt Lake observatory. Exchanges of signals were effected on the nights of September 13, 14, and 15, 1871.

The observations at both stations were compared in 1873 by Dr. F. Kampf, and rereduced in 1874, when this report was made up by him.

The instrumental values for the St. George instruments will be found in the Carlin report, and those for the Salt Lake transit in J. H. Clark's general report for 1873. The telegraphic line is three hundred miles long, and the signals were transferred direct, without repeaters. The discrepancy between the results for longitude on the first and second days is very remarkable, but too large on the second day to take into the final result. It may be that this change is an example of rapid variation in personal equation.

Salt Lake City, September 13, 1871.

Name of star.	Clamp.	T			bB	aA	cC	T′			AR.			Δ T		
		h.	*m.*	*s.*	*s.*	*s.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*	*h.*	*m.*	*s.*
ι Lyræ	W.	6	54	12.09	−0.33	0.00	+0.02	6	54	11.78	18	32	35.48	+11	38	23.70
β Lyræ	....	7	6	56.94	−0.26	+0.02	+0.02	7	6	56.72		45	20.37			23.65
50 Draconis	....		12	9.50	−0.65	−0.28	+0.06		12	8.63		50	32.36			23.73
ζ Aquilæ	....		21	6.88	−0.22	+0.06	+0.02		21	6.74		59	30.33			23.59
δ Draconis	....		34	9.65	−0.40	−0.15	+0.04		34	9.14	19	12	32.64			23.50
δ Aquilæ	E.		40	37.59	−0.17	+0.08	−0.02		40	37.48		19	1.31			23.83
κ Aquilæ	....		51	35.09	−0.15	+0.09	−0.02		51	35.01		29	58.86			23.85
Aquilæ	....	8	1	45.70	−0.20	+0.07	−0.02	8	1	45.55		40	9.35			23.80
ε Draconis	....		10	14.64	−0.34	−0.18	−0.05		10	14.07		48	37.84	+11	38	23.77
Mean for $7^{h}.5369$ Hutton's time														+11	38	23.713

Normal equations.

$$
\begin{array}{llll@{\qquad}l}
0 = +\,0.12 & +\,9.00\,\delta t & -\,1.25\,a & -\,4.10\,c & \delta t = +\,0^{s}.013 \\
0 = -\,1.35 & -\,1.25\,\delta t & +\,9.79\,a & +\,8.84\,c & a = +\,0^{s}.125 \\
0 = -\,1.66 & -\,4.10\,\delta t & +\,8.84\,a & +\,38.01\,c & c = -\,0^{s}.016
\end{array}
$$

Salt Lake City, September 13, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
ε Pegasi	W.	9 59 2.53	− 0.06	+ 0.13	+ 0.02	9 59 2.62	21 37 53.24	+11 38 50.62
μ Capricorni	....	10 7 27.46	− 0.02	+ 0.21	+ 0.02	10 7 27.67	46 18.06	50.39
79 Draconis	....	12 29.62	0.00	− 0.44	+ 0.06	12 29.24	51 19.74	50.50
α Aquarii	....	20 20.91	− 0.06	+ 0.16	+ 0.02	20 21.03	59 11.74	+11 38 50.71
Mean for 10ʰ.1616 Hutton's time								+11 38 50.555

Normal equations.

$0 = +0.52 + 4.00\,\delta t + 0.24\,a \qquad \delta t = -0^s.145$

$0 = -1.23 + 0.24\,\delta t + 4.89 a \qquad a = +0^s.238$

Adopted $c = -0^s.016$. It is not possible to solve normal equations if factors for c are introduced.

Salt Lake City, September 14, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
δ Draconis	W.	7 30 7.07	0.00	− 0.32	+ 0.05	7 30 6.80	19 12 32.59	+11 42 25.79
δ Aquilæ	....	36 35.50	− 0.04	+ 0.17	+ 0.02	36 35.65	19 1.29	25.64
κ Aquilæ	....	47 32.92	0.00	+ 0.21	+ 0.02	47 33.15	29 58.84	25.69
γ Aquilæ	E.	57 43.50	+ 0.06	+ 0.14	− 0.02	57 43.68	40 9.33	25.65
α Aquilæ	....	8 2 5.16	+ 0.06	+ 0.15	− 0.02	8 2 5.35	44 31.12	25.77
ε Draconis	....	6 12.38	+ 0.20	− 0.39	− 0.06	6 12.13	48 37.78	25.65
τ Aquilæ	....	15 26.03	+ 0.07	+ 0.16	− 0.02	15 26.24	57 52.12	+11 42 25.88
Mean for 7ʰ.8796 Hutton's time 288								+ 11 42 25.724

Normal equations.

$0 = +0.41 + 7.00\,\delta t + 0.41\,a \qquad \delta t = -0^s.076$

$0 = -1.41 + 0.41\,\delta t + 5.18\,a \qquad a = +0^s.278$

Error of collimation found by preliminary reduction $= -0^s.02$.

Salt Lake City, September 14, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
ξ Aquarii	E.	9 48 06.08	−0.14	+0.16	−0.02	9 48 06.08	21 30 55.26	+11 42 49.18
11 Cephei	....	57 16.36	−0.10	−0.31	−0.06	57 15.89	40 05.01	49.12
μ Capricorni	....	10 03 28.76	−0.02	+0.18	−0.02	10 03 28.90	46 18.05	49.15
79 Draconis	W.	08 30.76	0.00	−0.38	+0.07	08 30.45	51 19.71	49.26
α Aquarii	....	16 22.57	−0.04	+0.14	+0.02	16 22.69	59 11.74	49.05
θ Aquarii	....	27 14.42	−0.10	+0.16	+0.02	27 14.50	22 10 03.89	+11 42 49.39
Mean for 10ʰ.1279 Hutton 288								+11 42 49.192

Normal equations.

$0 = +0.07 + 6.00\,\delta t - 0.27\,a \qquad \delta t = -0^s.108$

$0 = -1.69 - 0.27\,\delta t + 8.06\,a \qquad a = +0^s.206$

Adopted $c = -0^s.02$

Salt Lake City, September 15, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
1 Aquilæ	W.	6 41 51.86	+0.03	+0.23	+0.02	6 41 52.14	18 28 12.71	+11 46 20.57
α Lyræ	....	46 15.03	0.00	+0.01	+0.03	46 15.07	32 35.43	20.36
β Lyræ	....	58 59.85	−0.06	+0.05	+0.02	58 59.86	45 20.32	20.46
50 Draconis	....	7 04 12.47	−0.10	−0.69	+0.08	7 04 11.76	50 32.17	20.41
ζ Aquilæ	....	13 09.94	−0.05	+0.15	+0.02	13 10.06	59 30.29	20.23
δ Draconis	E.	26 12.37	+0.12	−0.36	−0.05	26 12.08	19 12 32.52	20.44
δ Aquilæ	....	32 40.70	+0.04	+0.19	−0.02	32 40.91	19 01.27	20.36
κ Aquilæ	....	43 38.21	+0.02	+0.23	−0.02	43 38.44	29 58.83	20.39
γ Aquilæ	....	53 48.70	+0.03	+0.16	−0.02	53 48.87	40 09.32	20.45
α Aquilæ	....	58 10.48	+0.03	+0.17	−0.02	58 10.66	44 31.11	+11 46 20.45
Mean for 7h 3337 Hutton 288								+11 46 20.412

Normal equations.

$0 = +1.74 + 10.00\,\delta t + 0.47\,a$ $\qquad \delta t = -0^s.188$

$0 = -2.59 + 0.47\,\delta t + 8.67\,a$ $\qquad a = +0^s.309$

Adopted $c = -0^s.02$

Salt Lake City, September 15, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
ξ Aquarii...	E.	9 44 5.42	+ 0.03	+ 0.27	− 0.02	9 44 5.70	21 30 55.25	+11 46 49.55
11 Cephei....	....	53 15.48	+ 0.42	− 0.53	− 0.06	53 15.31	40 04.97	49.66
μ Capricornii	....	59 27.96	+ 0.03	+ 0.31	− 0.02	59 28.28	46 18.04	49.76
α Aquarii...	W.	10 12 21.94	− 0.04	+ 0.23	+ 0.02	10 12 22.15	59 11.74	49.59
θ Aquarii...	....	23 13.93	+ 0.03	+ 0.27	+ 0.02	23 14.25	22 10 03.88	49.63
π Aquarii...	....	31 53.79	+ 0.03	+ 0.22	+ 0.02	31 54.06	18 43.63	49.57
226 Cephei....	....	43 15.74	+ 0.45	− 0.92	+ 0.09	43 15.36	30 04.97	+11 46 49.61
Mean for 10h.2278 Hutton's time								+11 46 49.624

Normal equations.

$0 = -0.72 + 7.00\,\delta t - 0.43\,a$ $\qquad \delta t = +0^s.124$

$0 = -4.15 - 0.43\,\delta t + 12.05\,a$ $\qquad a = +0^s.349$

Adopted $c = -0^s.02$

St. George, Utah, September 13, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
α Sagitarii	W.	19 06 04.44	− 0.11	− 0.13	+ 0.42	19 06 04.62	19 10 07.05	+ 4 02.43
τ Draconis	....	14 00.18	− 1.39	+ 0.29	+ 1.28	14 00.36	18 02.76	02.40
κ Aquilæ	....	25 56.62	− 0.43	− 0.10	+ 0.40	25 56.49	29 58.86	02.37
β Aquilæ	E.	44 58.83	− 0.34	− 0.03	− 0.40	44 58.06	49 00.40	02.34
τ Aquilæ	....	53 50.47	− 0.18	− 0.03	− 0.41	53 49.85	57 52.14	02.29
κ Cephei	....	20 09 15.02	− 1.53	+ 0.18	− 1.82	20 09 11.85	20 13 14.25	02.40
π Capricorni	....	15 56.56	− 0.32	− 0.05	− 0.42	15 55.77	19 58.30	02.53
ε Delphini	....	23 03 52	− 0.52	− 0.03	− 0.41	23 02.56	27 04.92	+ 4 02.36
Mean for 19h 40m local sidereal time								+ 4 02.39

The azimuth of the instrument is changed after reversing. The error of collimation is derived by preliminary computation, $= -0^s.40$; and the azimuth determined for both positions separately.

Normal equations.

For clamp west: $0 = -0.06 + 3.00\,\delta t - 0.44\,a$ $\qquad \delta t = 0^s.000$

$0 = +0.78 - 0.44\,\delta t + 5.39\,a$ $\qquad a = -0^s.145$

For clamp east: $0 = +0.04 + 5.00\,\delta t - 0.59\,a$ $\qquad \delta t = -0^s.01$

$0 = +0.61 - 0.59\,\delta t + 10.13\,a$ $\qquad a = -0^s.060$

St. George, Utah, September 13, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T.
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
ε Pegasi	E.	21 33 50.76	− 0.57	− 0.07	− 0.75	21 33 49.37	21 37 53.23	+ 4 03.86
π Aquarii		22 14 41.04	− 0.51	− 0.09	− 0.74	22 14 39.70	22 18 43.64	03.94
ζ Pegasi		31 01.65	− 0.66	− 0.07	− 0.75	31 00.17	35 03.99	03.82
ι Cephei		41 08.34	− 1.66	+ 0.36	− 1.79	41 05.25	45 09.12	03.87
θ Piscium	W.	23 17 24.31	− 0.94	− 0.08	+ 0.74	23 17 24.03	23 21 27.82	03.79
ι Piscium		29 17.88	− 1.02	− 0.08	+ 0.75	29 17.53	33 21.38	+ 4 03.85
Mean for 22h 30m local sidereal time								+ 4 03.855

Normal equations.

$$0 = -0.30 + 6.00\,\delta t + 0.28\,a \qquad \delta t = +0^s.055$$
$$0 = +1.03 + 0.28\,\delta t + 6.57\,a \qquad a = -0^s.158$$

Error of collimation found by preliminary reduction $= -0^s.74$.

St. George, Utah, September 14, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
ξ Aquarii	W.	21 26 42.34	− 0.03	+ 0.64	− 1.46	21 26 41.49	21 30 55.26	+ 4 13.77
ε Pegasi		33 40.54	+ 0.09	+ 0.42	− 1.46	33 39.59	37 53.23	13.64
μ Capricorni		42 05.11	− 0.06	+ 0.71	− 1.46	42 04.30	46 18.05	13.75
α Aquarii		54 58.92	0.00	+ 0.55	− 1.44	54 58.03	59 11.74	13.71
π Aquarii		22 14 30.82	− 0.10	+ 0.52	− 1.44	22 14 29.80	22 18 43.64	13.84
226 Cephei		26 00.90	− 1.28	− 2.23	− 5.79	25 51.60	30 05.00	13.40
ζ Pegasi	E.	30 49.11	− 0.24	+ 0.41	+ 1.46	30 50.74	35 03.98	13.24
ι Cephei		40 54.56	− 0.79	− 2.03	+ 3.48	40 55.22	45 09.11	13.89
α Pegasi		54 07.67	− 0.29	+ 0.35	+ 1.49	54 09.22	58 22.53	13.31
θ Piscium		23 17 12.90	− 0.50	+ 0.46	+ 1.45	23 17 14.31	23 21 27.82	+ 4 13.51
Mean for 22h 25m local sidereal time								+ 4 13.606

Normal equations.

$$0 = +\ 4.31 + 10.00\,\delta t - 0.23\,a - 3.57\,c$$
$$0 = -16.67 - 0.23\,\delta t + 14.34\,a + 2.78\,c \qquad a = +0^s.884$$
$$0 = -45.50 - 3.57\,\delta t + 2.78\,a + 30.07\,c \qquad c = +1^s.444$$

St. George, Utah, September 15, 1871.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
δ Ursæ Minoris	E.	18 10 06.18	+4.18	−33.93	−5.46	18 09 30.97	18 13 53.94	+ 4 22.97
α Lyræ		28 12.63	+0.38	− 0.08	−0.42	28 12.51	32 35.43	22.92
ζ Aquilæ		55 06.36	+0.26	+ 1.08	−0.33	55 07.37	59 30.29	22.92
τ Draconis	W.	19 13 43.67	+0.26	− 5.37	+1.12	19 13 39.68	19 18 02.62	22.94
κ Aquilæ		25 33.83	+0.10	+ 1.32	+0.33	25 35.58	29 58.83	23.25
γ Aquilæ		35 44.76	+0.14	+ 1.22	+0.33	35 46.45	40 09.32	22.87
α Aquilæ		40 06.46	+0.17	+ 1.24	+0.33	40 08.20	44 31.11	+ 4 22.91
Mean for 19h 0m local sidereal time								+ 4 22.97

Normal equations.

$$0 = +\ 38.84 + 7.00\,\delta t - 13.04\,a + 12.69\,c \qquad \delta t = -0^s.030$$
$$0 = -516.71 - 13.04\,\delta t + 169.32\,a - 210.22\,c \qquad a = +2^s.647$$
$$0 = +654.68 + 12.69\,\delta t - 210.22\,a + 301.96\,c \qquad c = -0^s.324$$

St. George, Utah, September 15, 1871.

Name of star.	Clamp.	T	bB	aA	cC	T′	AR.	ΔT
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*m. s.*
β Aquarii	W.	21 20 21.48	−0.20	+1.53	+0.38	21 20 23.19	21 24 48.25	+ 4 25.06
ξ Aquarii	....	26 28.60	−0.06	+2.15	+0.38	26 31.07	30 55.25	24.18
α Aquarii	....	54 45.11	−0.13	+1.85	+0.38	54 47.21	59 11.74	24.53
π Aquarii	....	22 14 17.20	−0.24	+1.76	+0.38	22 14 19.10	22 18 43.63	24.53
α Pegasi	....	53 56.92	−0.38	+1.19	+0.39	53 58.12	58 22.52	24.40
θ Piscium	....	23 17 01.49	−0.31	+1.56	+0.38	23 17 03.12	23 21 27.82	24.70
γ Cephei	....	29 53.33	−1.50	−7.86	+1.66	29 45.63	34 10.25	24.62
Groom. 4163	E.	44 23.63	−1.32	−6.34	−1.34	44 14.63	48 40.14	25.51
α Andromedæ	....	57 21.36	−0.43	+0.54	−0.42	57 21.05	0 01 45.88	24.83
γ Pegasi	....	70 02 13.10	−0.37	+1.23	−0.39	0 02 13.57	06 38.08	24.51
α Cassiopeæ	....	28 53.74	−0.80	−1.70	−0.67	28 50.57	33 15.31	24.74
21 Cassiopeæ	....	33 02.86	−2.67	−6.67	−1.38	32 52.14	37 15.71	+ 4 23.57
Mean for 23^h 5^m local sidereal time								+ 4 24.60

Normal equations.

$$0 = +33.83 + 12.00\,\delta t - 3.60\,a + 0.72\,c \qquad \delta t = -1^s.900$$
$$0 = -66.22 - 3.60\,\delta t + 18.84\,a - 7.91\,c \qquad a = +2^s.992$$
$$0 = +46.58 + 0.72\,\delta t - 7.91\,a + 57.38\,c \qquad c = -0^s.375$$

The following table contains correction and rate of Hutton 288:

Date.	Hutton's time.	Correction of Hutton.	Rate per hour.
	h.	*h. m. s.*	*s.*
September 13, 1871	8.8492	+11 38 37.134	−10.2265
September 14, 1871	9.0038	42 37.458	−10.4379
September 15, 1871	8.7807	46 35.018	−10.0937

The corresponding observations at Saint George give for Negus 1344:

Date.	Local sidereal time.	Correction of Negus 1344.	Rate per hour adopted.
	h.	*h. m. s.*	*s.*
September 13, 1871	21.1	+0 4 3.122	−0.410
September 14, 1871	22.4	13.606	−0.432
September 15, 1871	21.0	23.785	−0.450

Exchange of signals between Salt Lake City and Saint George.

SEPTEMBER 13, 1871.

Signals sent from Salt Lake City.

Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 11 0.0	20 38 52.7	9 13 10.0	20 41 3.0	9 15 20.0	20 43 13.2
10.0	39 2.8	20.0	13.1	30.0	23.2
20.0	12.6	30.0	23.2	40.0	33.2
30.0	22.6	40.0	33.0	50.0	43.1
40.0	32.6	50.0	43.0	16 0.0	53.2
50.0	42.7	14 0.0	53.2		
12 0.0	52.8			Mean, 9 13 30.00	20 41 23.00
		15 0.0	42 53.4		
13 0.0	40 52.9	10.0	43 3.4		

SEPTEMBER 13, 1871.

Signals sent from Salt Lake City—Continued.

SECOND SERIES.

Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 26 4.2	20 53 59.9	9 28 14.0	20 56 9.6	9 30 26.0	20 58 21.3
13.8	54 8.8	25.3	20.6	35.7	31.5
25.1	20.1	35.2	30.5	45.6	41.3
35.2	30.1	45.7	40.9	55.4	51.0
45.1	40.2	....	....	31 5.6	59 1.1
55.1	50.1	29 5.1	57 0.7		
27 4.7	59.9			Mean, 9 28 29.35	20 56 24.70
		30	58 ...		
28 5.2	56 0.6	15.6	11.2		

Signals sent from Saint George.

Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 19 6.3	20 47 0.0	9 21 15.8	20 49 10.0	9 23 25.4	20 51 20.0
16.1	10.0	25.8	20.0	35.4	30.0
26.2	20.0	35.7	30.0	45.4	40.0
36.0	30.0	45.6	40.0	55.3	50.0
46.1	40.0	55.5	50.0	24 5.2	52 0.0
56.0	50.0	22 5.5	50 0.0		
20 6.0	48 0.0			Mean, 9 21 35.72	20 49 30.00
		23 5.4	51 0.0		
21 5.9	49 0.0	15.5	10.0		

SECOND SERIES.

Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 36 44.1	21 4 40.2	9 38 54.1	21 6 51.0	9 41 4.0	21 9 1.3
53.7	50.3	39 3.6	7 0.6	14.8	12.0
37 3.6	5 0.2	14.6	11.1	24.6	21.9
14.2	10.7	24.2	21.0	34.5	31.9
24.1	20.7	34.0	31.0	44.2	41.7
34.0	30.4	44.0	41.1		
43.9	40.5			Mean, 9 39 14.12	21 7 11.02
		40 44.2	8 41.4		
38 43.8	6 40.9	54.4	51.5		

SEPTEMBER 14, 1871.

Signals sent from Salt Lake City.

Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 6 0.00	20 37 41.1	9 8 10.0	20 39 51.5	9 10 20.0	20 42 1.8
10.0	51.1	20.0	40 1.5	30.0	11.8
20.0	38 1.2	30.0	11.5	40.0	21.8
30.0	11.2	40.0	21.6	50.0	31.9
40.0	21.3	50.0	31.5	11 0.0	42.0
50.0	31.1	9 0.0	41.7		
7 0.0	41.3			Mean, 9 8 30.00	20 40 11.53
		10 0.0	41 41.8		
8 0.0	39 41.4	10.0	52.0		

SEPTEMBER 14, 1871.

Signals sent from Salt Lake City—Continued.

SECOND SERIES.

Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 18 46.8	20 50 29.8	9 20 57.1	20 52 40.5	9 23 7.1	20 54 51.0
57.0	40.0	21 16.9	50.4	17.3	55 1.1
19 6.7	49.9	17.0	53 0.5	26.4	10.4
16.6	51 0.0	26.1	9.6	37.6	21.4
26.0	9.1	37.0	20.5	47.7	31.4
37.6	20.5	47.5	30.7		
47.2	30.4			Mean, 9 21 17.33	20 53 0.46
		22 47.4	54 30.9		
20 47.2	52 30.4	57.5	41.1		

Signals sent from Saint George.

Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 12 18.2	20 44 0.3	9 14 27.5	20 46 10.0	9 16 37.1	20 48 20.0
27.9	10.0	37.6	20.0	47.1	30.0
37.8	20.0	47.5	30.0	57.1	40.0
47.7	30.0	57.6	40.0	17 7.0	50.0
57.7	40.0	15 7.5	50.0	17.1	49 0.0
13 7.6	50.0	17.5	47 0.0		
17.6	45 0.0			Mean, 9 14 47.48	20 46 30.00
		16 17.2	48 0.0		
14 17.6	46 0.0	27.2	10.0		

SECOND SERIES.

Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.	Salt Lake chronometer.	Saint George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 25 36.6	20 57 20.5	9 27 46.0	20 59 30.6	9 29 56.5	21 1 41.4
45.7	30.0	55.9	40.5	30 7.7	52.3
55.7	40.1	28 7.1	51.6	16.7	2 1.7
26 7.1	51.3	16.8	21 0 1.6	27.6	12.6
16.2	58 0.6	27.1	11.7	37.2	22.2
27.6	11.7	37.1	21.7		
37.0	21.4			Mean, 9 28 6.79	20 59 51.36
		29 37.2	1 22.0		
27 37.2	59 21.7	46.6	31.8		

SEPTEMBER 15, 1871.

Signals sent from Salt Lake City.

Salt Lake chronometer.	St. George chronometer.	Salt Lake chronometer.	St. George chronometer.	Salt Lake chronometer.	St. George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
8 53 0.0	20 28 27.5	8 55 10.0	20 30 37.6	8 57 20.0	20 32 48.1
10.0	37.4	20.0	47.7	30.0	58.1
20.0	47.3	30.0	57.6	40.0	33 8.0
30.0	57.4	40.0	31 7.7	50.0	18.0
40.0	29 7.5	50.0	17.7	58 0.0	28.0
50.0	17.5	56 0.0	27.8		
54 0.0	27.5			Mean, 8 55 30.00	20 30 57.76
		57 0.0	32 28.0		
55 0.0	30 27.5	10.0	38.1		

SEPTEMBER 15, 1871.

Signals sent from Salt Lake City—Continued.

Salt Lake chronometer.	St. George chronometer.	Salt Lake chronometer.	St. George chronometer.	Salt Lake chronometer.	St. George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 8	22 44	9 10 47.6	22 46 17.7	9 12 57.2	22 48 27.6
47.5	17.1	57.4	27.5	13 6.7	37.4
57.5	27.2	11 6.6	36.9	17 9	46.4
9 6.6	36.8	18.3	48.3	27.6	58.4
18.0	48.0	27.4	57.6	38.0	49 8.5
28.1	58.1	37.6	47 8.0		
37.7	45 7.8			Mean, 9 11 15.00	22 46 45.23
		12 37.5	48 8.2		
10 37.6	46 7.8	47.1	17.3		

SEPTEMBER 15, 1871.

Signals sent from St. George.

Salt Lake chronometer.	St. George chronometer.	Salt Lake chronometer.	St. George chronometer.	Salt Lake chronometer.	St. George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 2 31.2	20 38 0.0	9 4 40.7	20 40 10.0	9 6 50.4	20 42 20 0
41.1	10.0	50.8	20.0	7 0.4	30.0
51.2	20.0	5 0.6	30.0	10.5	40 0
3 1.2	30.0	10.6	40.0	20.4	50.0
11.0	40.0	20.6	50.0	30.4	43 0.0
21.1	50.0	30.6	41 0.0		
31.0	39 0.0			Mean, 9 5 0.75	20 40 30.00
		6 30.5	42 0.0		
4 30.9	20 40 0.0	40.6	10.0		

Salt Lake chronometer.	St. George chronometer.	Salt Lake chronometer.	St. George chronometer.	Salt Lake chronometer.	St. George chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 14	20 50	9 16 41.6	20 52 12.9	9 18 52.4	20 54 23.6
41.4	12.0	51.6	22.4	19 3.1	34.2
51.3	22.0	17 2.1	33.1	12.6	44.1
15 1.8	32.6	12.0	43.2	22.8	54.2
11.6	42.5	22.1	53.3	32.7	55 4.2
21.7	52.6	32.4	53 3.6		
32.4	51 3.2			Mean, 9 17 9.62	20 52 40.71
		18 32.7	54 4.0		
16 32.3	52 3.3	41.9	13.3		

Signals sent from—	Recorded at—	Mean of signals sent and received.	Time corrections.	Corrected time.	Difference of longitude.	Means.
September 13, 1871.						
		h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
Salt Lake	St. George........	9 13 30.00 20 41 23.00	+11 38 40.98 + 0 4 2.95	20 52 10.98 20 45 25.95	0 6 45.03	
		9 28 29.35 20 56 24.70	+11 38 43.53 + 0 4 3.05	21 7 12.88 21 0 27.75	45.13	
St. George	Salt Lake	9 21 35.72 20 49 30.00	+11 38 42.36 + 0 4 3.01	21 0 18.08 20 53 33.01	45.07	
		9 39 14.12 21 7 11.02	+11 38 45.36 + 0 4 3.13	21 17 59.48 21 11 14.15	45.33	0 6 45.14

Signals sent from—	Recorded at—	Mean of signals sent and received.	Time corrections.	Corrected time.	Difference of longitude.	Means.
September 14, 1871.						
		h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s
Salt Lake	St. George	9 8 30.00 20 40 11.53	+11 42 38.90 + 0 4 12.88	20 51 8.90 20 44 24.41	44.49	
		9 21 17.33 20 53 0.46	+11 42 41.12 + 0 4 12.98	21 3 58.45 20 57 13.44	45.01	
St. George	Salt Lake	9 14 47.48 20 46 30.00	+11 42 39.99 + 0 4 12.93	20 57 27.47 20 50 42.93	44.54	
		9 28 6.79 20 59 51.38	+11 42 42.31 + 0 4 13.03	21 10 49.10 21 4 4.41	44.69	44.68
September 15, 1871.						
Salt Lake	St. George	8 55 30.00 20 30 57.76	+11 46 36.48 + 0 4 23.60	20 42 6.48 20 35 21.36	45.12	
		9 11 15.00 22 46 45.23	+11 46 39.12 + 0 4 23.72	20 57 54.12 20 51 8.95	45.17	
St. George	Salt Lake	9 5 0.75 20 40 30.00	+11 46 38.07 + 0 4 23.67	20 51 38.82 20 44 53.67	45.15	
		9 17 9.62 20 52 40.71	+11 46 40.12 + 0 4 23.76	21 3 49.74 20 57 4.47	45.27	45.18

	h. m. s.
Final difference of longitude, St. George, west of Salt Lake	0 6 45.00
Adopted longitude, (by excluding September 14, 1871)	0 6 45.16

Mean places of stars for 1871.0, used for determination of latitude of St. George, Utah.

No. in B. A. C.	Declination.	No. in B. A. C.	Declination.	No. in B. A. C.	Declination.	No. in B. A. C.	Declination.
	° ′ ″		° ′ ″		° ′ ″		° ′ ″
6404	41 18 15.82	6731	44 24 40.50	7029	31 46 30.12	7474	23 4 28.25
6426	32 39 56.12	6740	29 51 26.07	7041	42 11 1.46	7512	51 7 27.42
6473	41 26 19.86	6784	33 25 42.66	7121	14 8 52.88	7548	49 5 53.46
6491	32 30 50.60	6817	40 16 22.12	7160	14 7 31.14	7571	25 3 10.72
				7176	60 2 22.18		
6542	24 3 8.51	6839	16 17 41.03	7193	60 8 14.29	7598	48 42 47.58
6566	50 9 24.24	6863	57 54 36.98			7627	25 19 8.54
				7218	52 31 33.82		
6589	21 9 50.63	6882	24 26 37.77	7275	21 49 41.53	7736	58 39 42.20
6623	53 7 52.68	6895	49 44 47.56			7742	15 24 20.81
				7317	44 16 58.50	7755	58 46 41.68
6659	50 1 11.62	6912	23 14 38.59	7368	29 41 56.66		
6674	24 24 19.93	6959	51 4 35.00			7807	20 11 49.54
				7410	23 18 50.27	7846	53 35 9.44
6712	58 19 28.10	6986	39 58 0.90	7448	51 6 11.60		
6724	16 10 29.08	6998	34 34 51.16				

Observations for latitude.—Station, Saint George, Utah.

Date.	No. of star.	Micrometer-readings.		Level. N.	Level. S.	Remarks.
1871.						
19	6404	25	72.9	8.9	8.4	
	6426	15	20.0	9.0	8.5	
	6473	19	78.5	8.0	9.5	
	6491	8	46.8	9.5	8.3	
	6542	17	81.9	8.4	9.7	
	6566	17	70.9	10.1	8.0	
	6589	22	45.8	9.0	9.1	
	6623	18	49.9	9.1	9.0	
	6839	20	60.0	7.7	10.9	
	6863	20	72.3	11.0	7.5	
	6882	20	34.4	8.0	11.0	
	6895	21	4.5	10.0	8.5	
20	6404	25	69.9	8.9	8.0	
	6426	15	20.1	9.0	8.0	
	6473	19	70.5	9.4	7.8	
	6491	8	46.8	9.0	8.5	
	6542	17	24.6	9.0	8.5	
	6566	17	4.9	10.0	7.4	
	6659	16	10.0	11.0	6.8	
	6674	25	90.6	8.3	9.1	
	6712	10	40.3	8.9	8.4	
	6784	23	49.1	10.3	7.0	
	6731	18	13.7	6.0	11.4	
	6740	20	90.8	13.1	4.4	
	6784	12	41.2	8.6	9.3	
	6817	34	78.9	9.9	8.0	Must be 87.9
	6839	21	4.0	7.7	10.0	
	6863	21	4.0	13.7	4.0	
	6882	19	45.1	10.0	7.8	
	6895	20	9.5	10.0	7.3	
	6912	21	75.7	9.0	8.5	
	6959	16	63.3	11.2	6.5	
	6986	11	1.0	9.6	8.4	
	6998	26	30.7	10.0	8.7	
	7029	13	13.1	8.8	9.9	
	7041	24	5.0	12.0	6.8	
21	6404	26	14.0	8.3	7.1	
	6426	15	59.7	7.5	8.1	
	6473	20	14.5	9.0	6.8	
	6491	8	86.0	7.4	8.7	
	6542	17	48.0	8.5	8.0	
	6566	17	35.1	8.8	8.0	
	6589	22	41.6	7.0	10.2	
	6623	18	43.2	10.5	6.6	
	6659	15	97.8	11.1	6.3	
	6674	25	74.0	6.5	11.2	
	6712	10	1.3	8.0	9.7	
	6724	23	3.0	10.0	8.0	
	6731	18	13.5	9.7	8.4	
	6740	20	93.0	9.5	8.8	
1871. Sept. 21	6839	21	6.7	9.6	9.4	
	6863	21	14.1	9.8	9.0	
	6882	19	16.0	8.6	10.4	
	6895	19	77.1	12.0	6.8	
	6912	22	49.4	5.0	13.9	
	6959	17	34.7	15.3	3.4	
	6986	11	14.0	12.1	6.3	
	6998	26	39.7	7.2	11.3	
	7029	12	52.8	7.7	11.0	
	7041	23	49.7	10.0	7.7	
22	6404	25	33.5	8.8	7.9	
	6426	15	41.3	7.3	9.3	
	6473	20	10.4	5.5	11.5	
	6491	8	68.5	8.5	8.9	
	6542	17	56.1	7.9	9.8	
	6566	17	43.0	10.0	7.3	
	6589	23	5.9	9.0	8.7	
	6623	19	9.6	9.1	8.4	
	6659	16	6.4	11.0	6.9	
	6674	26	1.3	12.0	6.0	
	6712	10	26.7	9.0	9.0	
	6724	23	33.3	9.0	9.0	
	6784	12	35.3	8.7	10.4	
	6817	34	90.9	6.1	12.0	
	6839	21	10.0	11.9	8.8	
	6863	21	16.4	7.6	11.9	
	6882	19	30.0	9.4	10.4	
	6895	20	7.8	7.9	12.0	
	6912	22	50.7	9.9	10.3	
	6959	17	42.1	10.5	10.0	
	6986	11	27.4	10.8	9.9	
	6998	26	48.0	9.2	11.2	
	7029	12	85.6	5.5	15.0	
	7041	23	83.2	15.0	5.5	
	7121	22	24.8	10.6	10.5	
	7160	21	24.3	10.8	10.6	
	7176	23	8.0	10.3	10.5	
	7193	18	73.9	10.2	10.5	
	7218	16	16.8	11.0	10.0	
	7275	22	78.4	10.0	101	
	7410	29	10.8	11.0	10.0	
	7448	19	73.0	9.9	11.1	
	7474	18	46.3	11.3	10.0	
	7512	18	81.4	10.6	11.3	
	7548	19	76.5	11.7	9.4	
	7571	17	34.3	9.4	11.9	
	7598	22	86.2	11.4	10.0	
	7627	15	14.6	9.5	12.2	
	7736	25	0.1	12.1	10.0	
	7742	18	77.9	9.4	13.1	
	7755	19	76.3	12.3	9.0	

Observations for latitude.—Station, Saint George, Utah—Continued.

Date.	No. of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.
1871. Sept. 22	7807	9 40.7	12.0	11.0	
	7846	28 25.7	11.8	11.8	
23	6404	26 16.1	9.6	8.5	
	6426	15 70.2	10.3	7.7	
	6473	20 16.9	9.7	8.5	
	6491	8 92.5	10.0	8.2	
	6542	17 82.9	9.8	8.9	
	6566	17 65.4	10.3	8.3	
	6589	22 52.3	8.6	10.5	
	6623	18 47.1	13.1	5.8	
	6659	16 39.9	10.9	8.5	
	6674	26 20.8	10.0	9.5	
	6712	10 57.9	8.0	11.4	
	6724	23 65.6	12.9	6.9	
	6839	21 8.6	9.0	10.3	
	6863	21 8.2	13.3	6.4	
	6882	19 59.0	9.4	10.1	
	6895	20 22.5	12.1	7.4	
	6912	22 73.9	14.0	5.6	
	6959	17 59.3	8.1	12.0	
	6986	11 34.9	9.8	10.5	
	6998	26 60.3	13.3	7.0	
	7029	12 94.1	11.5	9.1	
	7041	23 68.0	16.4	4.1	
	7121	22 31.0	11.0	10.6	
	7160	21 28.9	11.0	10.7	
	7176	23 4.0	13.5	7.5	
	7193	18 70.1	13.4	7.5	
	7218	16 14.4	11.1	11.1	
	7275	22 76.3	11.4	11.6	
	7317	26 95.0	11.0	11.5	
	7368	16 96.4	10.6	11.9	
	7410	29 50.2	10.7	11.9	
	7448	20 14.0	11.1	11.0	
	7474	18 87.5	11.1	11.0	
	7512	19 13.7	13.8	8.5	
	7548	20 52.2	12.0	10.3	
	7571	18 15.6	12.9	9.5	
	7598	22 34.1	[illegible]	11.4	
	7627	14 70.4	[illegible]	8.1	
	7807	9 28.8		10.0	
	7846	8 4.7		10.6	
24	6659	16 46.2		13.4	
	6674	26 9.3		8.9	
	6731	17 70.0		8.5	
	6740	20 45.4		10.4	
	6784	8 62.0	[illegible]	10.0	
	6817	31 3.4	[illegible]	9.5	
	6882	19 50.5	[illegible]	11.0	
	6895	20 18.2		7.9	

Date.	No. of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.
1871. Sept. 24	7029	13 2.6	10.7	9.9	
	7041	23 98.3	10.4	10.2	
	2121	22 24.3	10.1	11.0	
	7160	21 27.5	11.1	10.1	
	7176	23 10.8	10.0	11.2	
	7193	18 74.9	10.0	11.1	
	7218	15 85.7	10.9	10.6	
	7275	22 49.9	11.2	10.6	
	7317	27 2.0	3.6	13.5	Very faint.
	7368	16 97.0	9.7	12.3	
	7410	29 13.4	11.9	10.3	
	7448	19 72.4	11.1	11.1	
	7474	23 52.5	12.4	9.9	
	7512	23 78.9	12.0	10.2	
	7548	19 74.3	15.1	6.6	
	7571	17 31.4	7.0	14.5	
	7598	22 66.3	9.0	12.5	
	7627	14 80.6	8.3	13.2	
	7736	25 8.9	7.8	14.1	
	7742	18 99.0	16.8	5.1	
	7755	19 77.4	11.0	10.9	
	7807	9 11.1	10.9	10.5	
	7846	28 1.3	9.0	12.4	
25	6404	26 22.0	7.7	9.3	
	6426	15 69.8	9.0	8.0	
	6473	20 28.4	8.6	9.0	
	6491	8 96.7	9.0	8.6	
	6731	17 13.5	13.7	5.0	
	6740	20 4.4	9.5	9.3	
	6784	8 65.9	8.0	10.5	
	6817	31 8.5	11.1	7.6	
	6882	19 53.7	10.0	9.6	
	6895	20 24.0	9.0	10.5	
	7029	13 25.6	11.6	8.8	
	7041	24 23.1	7.5	13.0	
	7121	21 88.9	8.8	10.0	
	7160	20 88.6	9.0	9.9	
	7176	22 71.1	10.6	8.1	
	7193	18 36.4	10.4	8.4	
	7218	16 13.1	9.3	11.8	
	7275	22 64.5	9.5	12.0	
	7410	28 69.4	10.5	11.6	
	7448	19 27.7	12.0	9.8	
	7474	18 1.7	10.0	12.1	
	7512	18 33.6	12.4	9.7	
	7598	22 65.0	11.9	10.5	
	7627	14 83.1	7.5	14.9	
	7736	25 3.9	13.0	9.9	
	7742	18 86.7	9.8	13.2	
	7755	19 80.8	14.0	9.0	
	7807	9 20.0	12.3	11.0	
	7846	27 98.0	11.8	11.6	

Computations for latitude of St. George, Utah.

Mean latitude of St. George, Utah: 37° 6′ 29″.38 ± 0″.08.

Date.	No. of pair.	Half-sum of declination.	Corrections. Micr. and refr.	Corrections. Level.	Corrections. Merid.	Latitude.
		° ′ ″	′ ″	″		° ′ ″
September 19, 1871	1	36 59 23.58	+ 7 5.81	+ 0.67	....	37 6 30.06
	2	58 52.98	+ 7 37.68	− 0.14	....	30.52
	3	37 6 33.93	− 0 4.45	+ 0.54	....	30.02
	4	9 9.16	− 2 40.11	0.06	....	29.05
	6	15 15.90	− 8 47.94	− 0.07	....	27.89
	9	6 26.50	+ 0 4.97	+ 0.20	....	31.67
	10	6 0 87	+ 0 28.34	− 1.01	....	28.20
September 20, 1871	1	36 59 23.61	+ 7 4.55	+ 1.27	....	29.43
	2	58 53.04	+ 7 34.44	+ 1.41	....	28.89
	3	37 6 34.00	− 0 7.96	+ 2.09	....	28.13
	5	13 3.77	− 6 36.57	+ 2.29	....	29.49
	6	15 15.99	− 8 49.31	+ 2.57	....	29.25
	7	8 21.69	− 1 52.07	+ 2.56	....	32.18
	8	36 51 20.96	+15 8.61	+ 0.80	....	30.37
	9	37 6 26.62	+ 0 0.00	+ 5.00	....	31.62
	10	6 1.00	+ 0 26.04	+ 3.31	....	30.35
	11	9 55.07	− 3 27.23	+ 3.51	....	31.35
	12	16 44.84	−10 18.63	+ 1.69	....	27.90
	13	36 59 4.51	+ 7 21.59	+ 2.77	....	28.87
September 21, 1871	1	36 59 23.65	+ 7 6.37	+ 0.40	....	30.42
	3	37 6 34.07	− 0 51.22	+ 0.88	....	29.73
	4	9 9.31	− 2 41.12	+ 0.47	....	28.66
	5	13 3 84	− 6 34.79	+ 0.07	....	29.12
	6	15 16.08	− 8 46.44	+ 0.20	....	29.84
	7	8 21.78	− 1 53.04	+ 1.35	....	30.09
	9	6 26.73	+ 0 2.99	+ 0.67	....	30.39
	10	6 1.12	+ 0 24.70	+ 2.30	....	28.12
	11	9 55.20	− 3 28.16	+ 2.02	....	29.06
	12	16 44.97	−10 17.01	+ 1.15	....	29.11
	13	36 59 4.65	+ 7 23.61	0.00	....	28.26
September 22, 1871	1	36 59 23.69	+ 7 5.52	− 0.74	....	28.47
	2	58 53.15	+ 7 41.80	+ 4.32	....	30.63
	3	37 6 34.13	− 0 5.30	+ 0.54	....	29.37
	4	9 9.38	− 2 41.08	+ 0.68	....	28.98
	5	13 3.92	− 6 42.35	+ 6.82	....	28.39
	6	15 16.16	− 8 48.42	0.00	....	27.74
	8	36 51 21.17	+15 12.21	− 5.13	....	28.25
	9	37 6 26.84	+ 0 2.59	− 0.81	....	28.62
	10	6 1.23	+ 0 31.45	− 3.44	....	29.24
	11	9 55.32	− 3 25.70	+ 0.07	....	29.69
	12	16 45.10	−10 14.95	− 0.74	....	29.41
	13	36 59 4.78	+ 7 23.89	0.00	....	28.67
	14	37 5 55.35	+ 0 33.65	− 0.07	....	28.93
	15	8 10.55	− 1 41.27	− 0.07	....	29.21
	16	10 56.26	− 4 27.57	+ 0.61	....	29.30
	18	12 49.32	− 6 19.26	− 0.14	....	29.92
	19	6 16.09	+ 0 14.19	0.00	....	30.28
	20	4 50.35	+ 1 17.95	− 0.13	....	28.17
	21	1 16.23	+ 5 12.06	− 0.88	....	27.41
	22	2 18.68	+ 4 11.64	− 1.08	....	29.24
	23	5 48.36	+ 0 39.79	− 0.94	....	27.21
	24	36 53 46.64	+12 42.34	+ 0.67	....	29.74
September 23, 1871	1	36 59 23.72	+ 7 2.98	+ 2.50	....	29.20
	2	58 53.20	+ 7 34.72	+ 2.02	....	29.94
	3	37 6 34.18	− 0 7.08	+ 1.96	....	29.06
	4	9 9.45	− 2 43.87	+ 3.78	....	29.36
	5	13 4.00	− 6 36.69	+ 1.96	....	29.27
	6	15 16.25	− 8 48.86	+ 1.76	....	29.15
	9	6 26.94	+ 0 0.08	+ 3.78	....	30.80
	10	6 1.35	+ 0 25.67	+ 2.70	....	29.72
	11	9 55.45	− 3 28.12	+ 3.04	....	30.37
	12	16 45.23	−10 16.89	+ 3.78	....	32.12
	13	36 59 4.92	+ 7 14.31	+ 9.92	....	29.15
	14	37 5 55.49	+ 0 29.52	+ 4.32	....	29.33
	15	8 10.69	− 1 44.66	+ 4.18	....	30.21
	16	10 56.41	− 4 27.70	− 0.14	....	28.57
	17	36 59 46.58	+ 6 43.84	− 1.22	....	29.20
	18	37 12 49.50	− 6 18.62	− 0.74	....	30.14
	19	6 16.27	+ 0 10.59	+ 3.64	....	30.50
	20	4 50.54	+ 1 35.69	+ 3.44	....	29.57
	21	1 16.42	+ 5 8.86	+ 4.05	....	29.33
	24	36 53 46.82	+12 38.66	+ 2.70	....	28.18

Computations for latitude of St. George, Utah—Continued.

Date.	No. of pair.	Half-sum of declination.	Corrections.			Latitude.
			Micr. and refr.	Level.	Merid.	
		° ′ ″	′ ″	″		° ′ ″
September 24, 1871	5	37 13 4.08	− 6 29.49	− 4.93	....	37 6 29.66
	7	8 22.05	− 1 51.38	0.00	....	30.67
	8	36 51 21.36	+15 6.47	− 0.40	....	27.43
	10	37 6 1.45	+ 0 27.30	+ 0.68	....	29.43
	13	36 59 5.05	+ 7 23.12	+ 0.67	....	28.84
	14	37 5 55.63	+ 0 34.98	− 1.42	....	29.19
	15	8 10.83	− 1 42.16	− 0.07	....	28.60
	16	10 56.56	− 4 28.63	+ 0.61	....	28.54
	17	36 59 46.73	+ 6 46.43	− 5.06	....	28.10
	18	37 12 49.67	− 6 20.56	+ 1.08	....	30.19
	19	6 16.45	+ 0 10.67	+ 2.90	....	30.02
	20	4 50.73	+ 1 38.23	+ 0.67	....	29.63
	21	1 16.61	+ 5 17.76	− 5.67	....	28.70
	22	2 19.07	+ 4 6.66	+ 3.64	....	29.37
	23	5 48.75	+ 0 31.71	+ 7.96	....	28.42
	24	36 53 47.00	+12 21.44	− 2.02	....	31.42
September 25, 1871	1	36 59 23.79	+ 7 5.52	− 0.40	....	28.91
	2	58 53.29	+ 7 37.68	0.00	....	30.97
	7	37 8 22.14	+ 1 57.65	+ 6.01	....	30.50
	8	36 51 21.45	+15 6.95	+ 0.68	....	29.08
	10	37 6 1.55	+ 0 28.43	− 0.75	....	29.23
	13	36 59 5.18	+ 7 23.85	− 1.82	....	27.21
	14	37 5 55.76	+ 0 33.24	+ 0.88	....	29.88
	15	8 10.97	− 1 41.99	+ 0.74	....	29.72
	16	10 56.72	− 4 23.45	− 3.37	....	29.90
	18	12 49.85	− 6 20.84	+ 0.74	....	29.75
	19	6 16.63	+ 0 12.90	+ 0.40	....	29.93
	21	1 16.81	+ 5 16.22	− 4.05	....	28.98
	22	2 19.28	+ 4 9.61	− 0.20	....	28.69
	23	5 48.95	+ 0 38.05	+ 1.08	....	28.08
	24	36 53 47.17	+12 39.75	+ 1.01	....	27.93

Adopting the longitude of Salt Lake, 111° 53′ 42″.90 west of Greenwich, the astronomical co-ordinates of St. George will be:

Longitude, 113° 35′ 0″.30 west of Greenwich.

Longitude, 36° 31′ 58″.50 west of Washington.

Latitude: N. 37° 6′ 29″.38 ± 0″.08.

The results obtained for the longitude by lunar culminations of Camp Independence, California, and Fort Whipple, Arizona Territory, and for the latitude of Camp Independence, California, will be incorporated in the astronomical volume.

In the same publication will appear a list of the geographical positions established by the survey.

Observations and computations for latitude.—Station, Fort Whipple, Arizona Ter.

OCTOBER 27, 1871.

Number of star.	Micrometer-readings.	Level.		Remarks.	Half-sum of declination.	Corrections.			Latitude.
		N.	S.			Micrometer and reference.	Level.	Merid.	
	t. d.				° ′ ″	′ ″	″		° ′ ″
6990	12 40.4	12.5	13.8						
7029	26 52.2	15.7	11.0	....	34 42 35.1	− 9 30.5	+2.3	....	34 33 6.9
7061	16 86.3	11.9	18.2						
7131	19 6.5	19.0	12.0	....	34 34.6	− 1 29.0	+0.5	....	6.1
7275	13 76.4	16.3	16.0						
7301	24 67.0	15.0	17.1	....	25 46.7	+ 7 20.7	−1.2	....	6.2
7372	17 49.9	17.0	16.0						
7387	19 32.5	16.0	17.2	....	31 53.5	+ 1 13.8	−0.1	....	7.2

Observations and computations for latitude of Fort Whipple, Arizona—Continued.

OCTOBER 27, 1871.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.				° ′ ″	′ ″	″		° ′ ″
7455	14 82.7	20.1	13.6						
7474	21 3.9	12.9	20.8	....	34 37 18.0	—4 11.0	—0.9	....	34 33 6.1
7520	24 70.4	16.4	17.6						
7560	13 58.7	17.7	16.7	....	40 35.8	— 7 29.2	—0.1	....	6.5
7606	14 81.4	5.5	5.6						
7676	21 26.5	2.9	7.3	....	28 48.9	+ 4 20.7	—3.0	....	6.6
7749	19 32.3	4.9	4.9						
7796	20 65.3	4.0	5.8	....	34 2.0	— 0 53.7	—1.2	....	7.1
7807	19 8.6	2.8	4.0						
7820	22 24.8	4.0	3.0	....	30 58.4	+ 2 7.6	—0.1	....	5.9
7915	19 70.0	7.5	6.4						
7923	20 4.2	4.9	9.0	....	33 22.2	— 0 13.8	—2.0	....	6.4
8023	22 60.7	7.1	7.0						
8032	19 24.2	5.3	8.9	....	30 52.7	+ 2 16.0	—2.4	....	6.3
8076	20 60.7	6.7	8.0						
8079	16 59.0	6.5	8.0	....	30 27.1	+ 2 42.3	—1.9	....	7.5
8097	15 74.2	8.5	7.4	?					
8128	23 73.4	6.5	8.3	....	27 53.9	+ 5 10.8	—0.5	....	4.2
8158	26 10.1	6.1	8.3						
8182	16 50.8	6.8	7.9	....	26 40.6	+ 6 27.6	—2.2	....	6.0
8195	19 80.5	7.9	7.0						
8206	22 0.8	5.3	9.1	....	34 36.1	— 1 29.0	—2.0	....	5.1
8250	15 42.4	8.0	6.7						
8280	25 1.5	5.1	9.9	....	26 38.9	+ 6 27.6	—2.4	....	4.1
8299	20 90.1	7.3	7.9						
8307	15 74.8	6.0	9.1	....	36 36.8	— 3 28.2	—2.5	....	6.1
8335	16 59.0	7.1	8.0						
7	21 0.9	8.0	7.1	....	30 5.3	+ 2 58.6	0.0	....	3.9
166	16 83.9	8.6	6.0						
173	25 23.6	3.2	10.0	....	28 28.6	+ 5 39.3	—2.8	....	5.1
201	14 0.9	6.4	7.6						
211	22 60.1	5.7	8.2	....	38 55.2	— 5 47.2	—2.5	....	5.5
232	15 93.0	5.8	8.5						
235	13 11.1	5.9	8.4	....	39 7.9	— 6 8.0	+7.3	....	7.2
247	25 3.7	14.0	0.4	....	41 3.4	— 8 1.9	+4.1	....	5.6

OCTOBER 28, 1871.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.								
7275	13 63.2	5.1	8.5						
7301	24 47.1	9.9	4.0	....	25 46.6	+7 18.0	+1.7	....	34 33 6.3
7345	19 48.3	9.6	4.0	....	29 9.4	+3 56.4	+1.5	....	7.3
				Cloudy.					
8299	20 29.2	8.3	8.7						
8307	15 2.0	9.6	6.3	....	36 37.0	—3 33.0	+2.0	....	6.0
48	18 98.8	7.0	9.0						
92	17 45.0	10.9	5.3	....	34 7.6	—1 2.2	+2.4	....	7.8
166	16 55.9	18.4	19.6						
173	25 6.0	15.0	22.9	....	28 28.8	+5 43.5	- 6.1	....	6.2
201	14 77.4	7.8	9.5						
211	23 45.5	11.0	6.4	....	38 55.3	—5 51.6	+2.0	....	5.7
232	15 53.3	4.6	12.7						
247	24 48.5	13.0	4.0	....	39 8.1	—6 1.8	+0.8	....	7.1

Observations and computations for latitude of Fort Whipple, Arizona—Continued.

OCTOBER 29, 1871.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.				° ′ ″	″	″		° ′ ″
7275	13 12.4	7.7	3.2						
7301	23 99.2	3.3	7.5	....	34 25 46.6	+7 19.2	+0.2	....	34 33 6.[illegible]
7345	18 99.6	3.9	7.7	....	29 9.4	+3 57.3	+0.4	....	7.1
7372	16 55.9	6.8	5.0						
7387	18 33.0	5.6	6.3	....	31 53.5	+1 11.6	+0.7	....	5.8
7455	14 50.2	5.3	6.8						
7474	20 79.1	8.4	4.0	....	37 18.0	4 14.1	+1.9	....	5.8
7520	24 27.4	7.0	5.4						
7560	13 10.0	7.2	5.2	....	40 35.8	−7 31.5	+2.4	....	6.7
7641	16 6.1	6.3	7.0						
7683	27 3.6	9.0	4.6	....	25 40.4	+7 23.5	+2.5	....	6.4
7749	18 72.7	9.1	4.5						
7796	20 13.5	5.5	8.5	....	34 2.1	−0 56.9	+1.1	....	6.3
7807	20 73.0	3.6	10.7						
7820	22 78.0	14.7	− 0.8	....	30 58.5	+2 3.2	+5.7	....	7.4
7915	19 7.0	8.0	7.2						
7923	19 52.4	7.8	6.9	....	33 22.4	−0 18.4	+1.1	....	5.1
7943	25 57.0	6.5	7.8						
7953	15 62.6	7.2	7.2	....	39 48.5	−6 41.8	−0.9	....	5.8
8023	22 67.0	8.5	6.6						
8032	19 40.7	7.3	7.8	....	30 52.9	+2 11.9	+0.9	....	5.7
8076	20 25.8	8.2	7.0						
8079	16 35.4	7.2	8.0	....	30 27.3	+2 37.7	+0.3	....	5.3
8158	25 85.0	5.6	9.5						
8182	16 33.8	10.0	5.2	....	26 40.8	+6 24.4	+0.6	....	5.8
8195	16 51.0	8.1	7.2						
8206	18 82.2	8.5	7.0	....	34 36.3	−1 33.4	+1.6	....	4.5
8250	15 31.3	7.4	8.1						
8280	24 94.0	8.1	7.3	....	26 39.1	+6 29.0	0.0	....	8.1
48	19 14.5	7.6	8.0						
92	17 62.1	7.9	8.2	....	34 7.7	− 1 1.6	−0.5	....	5.6
122	12 48.5	8.5	7.5						
146	26 97.8	7.5	8.7	....	23 19.7	+ 9 45.6	−0.1	....	5.2
201	13 76.2	8.7	7.8						
211	22 40.7	7.8	8.8	....	38 55.4	− 5 49.3	−0.1	....	6 0
232	15 42.3	8.4	8.0						
235	12 58.0	8.2	8.0	....	39 8.2	− 6 0.7	+0.1	....	7.6
247	24 34.9	8.0	8.3	....	41 3.6	− 7 55.6	−0.1	....	7.9

OCTOBER 30, 1871.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
7275	12 90.6	7.3	7.0						
7301	23 83.4	5.8	7.4	....	34 25 46.6	+ 7 21.6	−0.9	....	34 33 7.3
7345	18 78.4	6.2	8.4	....	29 9.3	+ 3 57.5	−1.3	....	5.5
7372	16 71.3	6.8	8.0						
7377	23 35.7	7.8	7.0	....	28 36.4	+ 4 28.5	−0.3	....	4.6
7455	14 47.3	9.5	5.8						
7474	20 70.6	6.0	9.6	....	37 18.0	− 4 11.9	+0.1	....	6.2
7520	24 44.9	8.0	7.4						
7560	13 39.2	7.3	8.5	....	40 35.8	− 7 26.8	−0.4	....	8.6
7641	15 80.1	7.3	8.5						
7683	26 84.0	8.6	7.9	....	25 40.4	+ 7 26.1	−0.3	....	6.2

Observations and computations for latitude of Fort Whipple, Arizona—Continued.

OCTOBER 30, 1871.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.				° ′ ″	′ ″	″		° ′ ″
7749	18 57.6	6.0	10.3						
7796	19 88.4	7.5	8.9	....	34 34 2.2	− 0 52.9	−3.8	....	34 33 5.5
7807	18 95.8	6.7	9.8						
7820	22 0.5	12.5	3.7	....	30 58.6	+ 2 3.1	+3.9	....	5.6
7915	18 95.1	8.6	7.7						
7923	19 35.3	7.7	8.6	....	33 22.5	− 0 16.2	0.0	....	6.3
7943	25 64.5	8.6	7.5						
7953	15 70.2	7.4	9.0	....	39 48.6	− 6 41.8	−0.3	....	6.5
8158	24 41.0	7.8	8.5						
8182	14 82.2	8.0	8.1	....	26 41.0	+ 6 27.5	−0.5	....	8.0
8250	15 94.3	8.0	7.8		2				
8280	25 42.6	10.2	6.4	....	26 39.2	+ 6 23.2	+2.7	....	5.1
8299	20 22.0	7.9	9.0						
8307	15 11.7	5.6	11.0	....	36 37.2	− 3 26.2	−4.4	....	6.6
8335	16 31.0	7.7	9.2						
7	20 74.7	8.6	8.8	....	30 5.7	+ 2 59.3	−1.1	....	3.9
48	19 33.9	9.0	8.6						
92	17 83.4	8.7	9.1	....	34 8.0	− 1 0.08	0.0	....	7.2
116	13 1.2	8.9	9.1						
122	12 34.3	9.1	9.0	....	23 47.2	+ 9 17.3	+0.1	....	4.6
146	26 80.3	9.1	8.8	....	23 19.8	+ 9 44.3	+0.3	....	4.4

OCTOBER 31, 1871.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
166	16 53.7	9.5	8.5						
173	24 91.4	8.0	10.0	....	34 27 29.0	+ 5 38.5	−0.7	....	34 33 6.8
201	13 86.5	9.0	9.0						
211	22 49.3	7.9	10.0	....	38 55.6	− 5 48.7	−1.4	....	5.5
232	15 12.1	7.2	10.7						
235	12 29.2	6.6	11.4	....	39 8.4	− 6 2.9	+3.1	....	8.6
247	24 10.0	13.1	5.0	....	41 3.8	− 7 57.2	+2.2	....	8.8
7204	28 23.0	8.7	4.5						
7213	9 77.6	4.6	8.6	....	45 32.1	−12 25.7	+0.1	....	6.5
7275	13 16.7	11.4	10.4						
7301	23 98.4	12.0	9.8	....	25 46.7	+ 7 17.1	+2.2	....	6.0
7345	19 9.7	9.0	13.0	....	29 9.4	+ 3 59.6	−2.0	....	7.0
7372	16 33.5	10.3	12.0						
7387	18 6.4	13.2	9.0	Very faint	31 53.6	+ 1 9.9	+1.7	....	5.2
7455	14 37.0	11.0	12.0						
7474	20 69.2	14.6	8.5	....	37 18.1	− 4 15.5	+3.4	....	6.0
7520	23 98.9	11.0	12.1						
7560	12 82.0	13.0	9.4	....	40 35.9	− 7 31.3	+1.7	....	6.3
7606	13 84.1	12.0	11.5						
7676	20 14.7	13.1	11.0	....	28 49.2	+ 4 14.8	+1.8	....	5.8
7749	18 16.7	12.0	12.2						
7796	19 49.3	10.0	14.7	....	34 2.2	− 0 53.6	−3.3	....	5.3
7807	18 55.2	16.2	8.3						
7820	21 68.0	7.8	12.0	....	30 58.7	+ 2 6.4	+2.5	....	7 6
7915	18 89.5	7.7	7.7						
7923	19 28.0	6.8	8.5	....	33 22.6	− 0 15.6	−1.1	....	5.9
7943	25 84.9	8.4	6.8						
7953	15 89.0	8.0	7.4	....	39 48.7	− 6 42.5	+1.5	....	7.7
8023	22 80.1	9.0	6.7						
8032	19 52.6	6.8	9.0	....	30 53.2	+ 2 12.3	−0.0	....	5.5

Observations and computations for latitude of Fort Whipple, Arizona—Continued.

OCTOBER 31, 1871.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.				° ′ ″	′ ″	″		° ′ ″
8097	18 95.0	8.8	7.4	Very faint					
8128	26 65.6	7.6	8.9	....	34 27 54.3	+ 5 11.4	+0.1	....	34 33 5.8
8158	25 30.6	7.0	9.1						
8182	15 63.3	5.7	10.5	....	26 41.2	+ 6 30.9	−4.7	....	7.4
8195	16 77.6	9.9	6.4	d.					
8206	19 1.6	2.3	8.8	(?) Is 7.3.	34 36.6	− 1 30.5	+1.3	....	7.4
8250	15 23.6	7.5	8.8						
8280	24 60.5	13.1	3.2	....	26 39.4	+ 6 18.6	+5.8	....	3.8
8299	20 47.1	9.0	7.4						
8307	15 25.9	7.4	9.0	....	36 37.3	− 3 30.6	0.0	....	6.7
8317	12 23.1	12.1	4.3						
8370	24 74.4	6.5	10.2	....	41 31.6	− 8 25.6	+2.8	....	8.8
48	18 65.5	8.1	9.0						
92	17 12.2	8.9	8.3	....	34 8.0	−1 2.0	−0.2	....	5.8
116	13 34.4	10.1	7.0						
122	12 70.9	10.1	7.0	....	23 47.4	+ 9 17.2	+0.5	....	5.1
146	27 13.2	7.5	9.8	....	23 20.0	+ 9 42.9	+0.5	....	3.4
166	16 15.2	5.1	12.2						
173	24 68.0	7.1	10.2	....	27 29.2	+ 5 44.6	−6.9	....	6.9
201	13 60.2	7.2	10.0						
211	22 20.8	8.8	8.4	....	38 55.7	− 5 47.8	−1.6	....	6.3
232	14 84.4	11.5	6.0						
235	11 95.0	11.9	5.6	....	39 8.6	− 5 58.3	−1.9	....	8.4
247	23 71.1	4.6	12.9	....	41 4.0	− 7 55.3	−1.3	....	7.4

NOVEMBER 1, 1871.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
7275	12 41.5	8.5	7.0						
7301	23 26.0	7.9	7.9	....	34 25 46.6	+ 7 18.3	+1.0	....	34 33 5.9
7345	18 26.2	8.4	7.8	....	29 9.4	+ 3 56.3	+1.4	....	7.1
7372	16 48.8	8.1	8.0						
7387	18 31.4	7.2	9.1	....	31 53.6	+ 1 13.8	−1.2	....	6.2
7520	24 34.6	8.3	8.7						
7560	13 19.6	9.7	8.1	....	40 36.0	− 7 30.6	+0.8	....	6.2
7749	18 51.3	6.1	12.1						
7796	19 82.7	10.1	8.2	....	34 2.2	− 0 53.1	−2.8	....	6.3
7807	18 14.0	10.3	8.4						
7820	21 29.7	7.8	12.1	....	30 58.8	+ 2 7.6	−1.6	....	4.8
7915	18 86.8	9.0	10.0						
7923	19 26.0	9.6	9.6	....	33 22.7	− 0 15.8	−0.7	....	6.2
7943	17 40.3	6.1	12.8						
7953	7 44.5	13.0	5.9	....	39 48.8	− 6 42.4	+0.3	....	6.7
8023	22 93.0	9.5	9.8						
8032	19 60.4	8.6	10.9	....	30 53.3	+ 2 10.8	+1.4	....	5.5
8076	20 43.1	10.6	8.9						
8079	16 51.0	8.3	11.1	....	30 27.6	+ 2 38.5	−0.7	....	5.4
8097	18 85.0	9.0	10.8						
8128	26 55.5	9.8	10.1	....	27 54.3	+ 5 11.4	−1.4	....	4.5
8195	16 6.4	10.5	9.2						
8206	18 31.1	9.2	10.6	....	34 36.7	− 1 30.8	−0.1	....	5.8
8299	20 12.4	8.0	12.1						
8307	14 24.0	13.7	6.7	....	36 37.6	− 3 33.5	+2.0	....	6.1

Observations and computations for latitude of Fort Whipple, Arizona—Continued.

Number of star.	Micrometer-readings.	Level.		Remarks.	Half sum of declination.	Corrections.			Latitude.
		N.	S.			Micrometer and reference.	Level.	Meridian.	
NOVEMBER 1, 1871.									
	t. d.				° ′ ″	′ ″	″		° ′ ″
8317	12 2.6	10.2	9.7						
8370	24 52.1	10.1	10.0	....	34 41 31.7	− 8 24.9	+0.4	....	34 33 7.2
4	11 66.2	10.0	10.3						
28	29 3.5	8.8	11.7	....	21 24.6	+11 42.1	−2.2	....	4.5
48	18 46.4	11.8	8.7						
92	16 96.2	8.0	12.7	....	34 8.2	− 1 0.7	−1.1	....	6.4
116	13 42.1	9.0	12.0						
122	12 76.1	9.0	12.0	....	23 47.5	+ 9 19.4	−1.7	....	5.2
146	27 26.5	10.5	10.0	....	23 20.2	+ 9 46.1	−1.7	....	4.6
166	16 27.3	8.4	12.9						
173	24 66.3	11.2	10.0	....	27 29.4	+ 5 39.0	−2.2	....	6.2
201	12 93.5	9.5	11.8						
211	21 52.0	10.8	10.8	....	38 56.0	− 5 46.9	−1.6	....	7.5
232	15 9.0	10.6	10.6						
235	12 20.2	10.6	10.6	....	39 8.7	− 5 59.6	−2.3	....	6.8
247	23 99.0	9.0	12.4	....	41 4.1	− 7 56.3	−2.3	....	5.5
NOVEMBER 2, 1871.									
8250	15 30.3	9.2	12.4						
8280	24 96.0	8.3	13.5	....	34 26 39.6	+ 6 30.2	−5.7	....	34 33 4.1
4	11 88.0	10.4	12.0						
28	29 27.8	10.5	12.0	....	21 24.7	+11 43.1	−2.1	....	5.7
116	13 23.0	10.4	12.0						
146	27 5.6	10.5	12.0	....	23 47.6	+ 9 18.6	−2.1	....	4.1
166	16 83.1	10.7	12.4						
173	25 18.5	12.0	10.5	....	27 29.5	+ 5 37.6	−0.1	....	7.0
201	13 60.5	9.8	13.0						
211	22 27.2	13.6	9.0	....	38 56.0	− 5 50.2	+0.9	....	6.7
214	19 52.0	19.5	3.0						
219	17 52.9	− 0.5	22.7	Very faint	34 26.9	− 1 20.5	−0.8	....	5.6
232	15 78.7	11.6	10.9						
235	12 91.8	12.0	10.7	....	39 8.9	− 6 12.0	+9.0	....	5.9
247	24 99.3	17.6	5.0	....	41 4.2	− 8 8.0	+9.4	....	5.6
NOVEMBER 5, 1871.									
8097	19 39.7	9.8	8.1	Very faint					
8128	27 1.4	10.2	7.5	....	34 27 55.0	+ 5 7.8	+3.0	....	34 33 5.8
8136	17 87.9	12.9	4.8						
8159	20 82.6	7.0	10.7	....	35 2.3	− 1 59.1	+3.0	....	6.2
8250	15 54.8	10.3	7.6						
8280	25 4.0	8.6	9.8	....	26 40.0	+ 6 23.6	+1.0	....	4.6
8299	20 68.0	9.0	9.1	Very faint					
8307	15 41.8	11.3	7.2	....	36 37.8	− 3 32.6	+2.7	....	7.8
8317	13 11.2	7.5	11.0						
8370	25 66.7	12.6	6.1	....	41 32.2	− 8 27.4	+2.0	....	6.8
4	12 8.5	11.5	7.3						
28	29 32.0	9.9	8.9	....	21 25.1	+11 36.5	+3.5	....	5.1
214	19 18.2	11.0	8.1						
219	17 7.0	10.4	9.0	....	34 27.3	− 1 25.3	+2.9	....	4.9

Mean latitude of Fort Whipple, Arizona, 34° 33′ 6″.124 ±0.065.

FORT FRED STEELE, WYOMING, (1872.)

Longitude, 106° 56′ 48″.80; latitude, 41° 46′ 40″.24 ±0″.05.

The point selected for the station at Fort Fred Steele was just in the rear of the sutler's store, on the west side of the railroad-track. Being across a ravine which lay between it and the railroad, it was entirely free from the jar of passing trains; and being at the same time to the windward, there was no interference from smoke. Fort Fred Steele is a military post pure and simple, is situated on the left bank of the North Platte, where the Union Pacific Railroad crosses it, and has no citizen-population whatever, if the few railroad employés and the proprietors of one or two insignificant ranches in the immediate vicinity be excepted. The location is on a bluff of the river, which presents here limited and rather barren valleys, while the surrounding country has been much disturbed by volcanic action, and, subsequently, further cut up by erosion. The general view is very limited; the top of Elk Mountain can be seen at the southeast and directly north on the east side of the river, and but two or three miles distant a rocky ridge, around which the river works its way to the west. Southward the view is up the valley of the river, the barrenness of which is somewhat relieved by a few straggling cotton-wood trees. Taken altogether, its surroundings are not inviting, and, if we except the country about Green River, no region which the Union Pacific Railroad traverses is more destitute of animal and vegetable life.

Meteorological.—The most unfavorable condition possible as to weather prevailed during the occupation of this station, which was in the month of November. In this time there was scarcely a week altogether that could be made available for astronomical work in connection with Salt Lake. It was entirely too cold to make anything like satisfactory observations, the thermometer showing frequently a range of temperature from 30° to 40° below freezing, and once it actually touched 60°, when it was no longer possible to remain in the tent or keep the ink and battery from freezing, despite the use of a stove—a very objectionable feature to an observatory under any circumstances. It was not only cold, but an almost uninterrupted series of drifting snow and dust storms succeeded each other.

Observatory and instruments.—The observatory and instruments were the same as those used at Cheyenne, Wyo., and the transit was mounted in the same way. The assistants, (J. H. Clark being the principal,) were also the same. The telegraphic work was done over the Atlantic and Pacific line, and the operators were Messrs. Brown, McCoy, Murphy, and three others. These were not all present at the same time, but came as reliefs during the occupancy of this station.

Connections.—Connection was made with Salt Lake observatory. On the 1st, 4th, 5th, 7th, 19th, 20th, 21st, 22d, 25th, and 26th of November, observations were made with the view of interchanging signals for longitude, and chronometer-signals were sent and received on six nights. For eleven nights, work was prosecuted on the latitude. On many of them only a pair or two of stars here and there between the passing storm-clouds could be observed.

Instrumental values.—The instrumental values are given in the report on Cheyenne station already published.

Circumstances of telegraphic connection.—The length of the circuit is about four hundred miles. The observatory was connected by a loop with the railroad telegraph-office, and all the signals were received and

sent by the instrumentality of the chronograph. No information is available as to the batteries and repeaters on the circuit employed,

The computations were made by civilian assistants, J. H. Clark and Dr. F. Kampf. The arrangement into publication form was made by the latter.

Uniform tables of time-reductions at Fort Fred Steele, Wyo., November 5, 1872.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
ε Pegasi	W.	23 38 16.20	−0.28	+ 2.37	−0.04	23 38 18.25	21 37 55.64	−2 00 22.61
11 Cephei	....	40 32.96	−0.87	− 6.45	−0.12	40 25.52	40 02.79	22.73
μ Capricorni	....	46 40.04	−0.19	+ 3.73	−0.04	46 43.54	46 20.92	22.62
79 Draconis	....	51 48.27	−0.41	− 7.86	−0.13	51 39.87	51 16.95	22.92
α Aquarii	....	59 34.12	+0.04	+ 2.99	−0.04	59 37.11	59 14.42	22.69
32 Urs. Maj., L. C	E.	0 08 58.09	+0.04	+10.18	−0.10	0 09 08.21	22 08 44.65	23.56
π Aquarii	....	19 06.25	−0.04	+ 2.90	+0.04	19 09.15	18 46.36	22.79
ϑ Draconis, L. C	....	24 17.43	+0.20	+16.42	−0.17	24 33.88	24 11.01	22.87
η Draconis	....	29 08.83	−0.10	+ 2.99	+0.04	29 11.76	28 48.74	23.02
ζ Pegasi	....	35 27.42	−0.17	+ 2.33	+0.04	35 29.62	35 06.65	−2 00 22.97
Mean for $22^h\ 0^m$ local sidereal time								−2 00 22.88

Normal equations.

$$
\begin{array}{rrrl}
10\ \delta t & -\ 6.74\,a & -13.16\,c & = +\ 30.82 \\
-\ 6.74\,\delta t & +\ 27.38\,a & +11.12\,c & = -\ 121.02 \\
-\ 13.16\,\delta t & +\ 11.12\,a & +51.01\,c & = -\ 49.81
\end{array}
\qquad
\begin{array}{l}
a = -\ 4^s.390 \\
c = +\ 0^s.035
\end{array}
$$

Fort Fred Steele, Wyo., November 5, 1872.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
ι Piscium	E	1 33 43.92	+0.07	+ 2.68	0.00	1 33 46.67	23 33 24.44	−2 00 22.23
Groomb. 4163	....	49 12.05	+0.21	− 8.45	−0.01	49 03.80	48 41.34	22.46
ω Piscium	....	53 06.65	+0.04	+ 2.64	0.00	53 09.33	52 46.80	22.53
α Adrom	....	2 02 10.38	+0.05	+ 1.16	0.00	2 02 11.59	0 01 48.95	22.64
4 Drac., L. C	....	06 12.13	−0.12	+19.09	+0.02	06 31.12	06 08.90	22.22
α Cassiopeiæ	W.	33 43.22	−0.04	− 1.92	0.00	33 41.26	33 18.58	22.68
β Ceti	....	37 31.54	+0.05	+ 4.11	0.00	37 35.70	37 12.51	23.19
32 Camel., L. C	....	47 51.86	−0.57	+35.27	−0.03	47 26.53	48 04.97	22.56
ε Piscium	....	56 40.98	+0.08	+ 2.55	0.00	56 43.61	56 20.77	22.84
Mean for $0^h\ 0^m$ local sidereal time								−2 00 22.59

Normal equations.

$$
\begin{array}{rrrl}
9\ \delta t & -\ 12.78\,a & +\ 7.66\,c & = +\ 60.50 \\
-12.78\,\delta t & +\ 86.18\,a & -\ 49.74\,c & = -\ 389.94 \\
+\ 7.66\,\delta t & -\ 49.74\,a & +\ 140.57\,c & = +\ 224.57
\end{array}
\qquad
\begin{array}{l}
a = -\ 4^s.470 \\
c = -\ 0^s.003
\end{array}
$$

Fort Fred Steele, November 19, 1872.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
ζ Pegasi	W.	0 34 32.85	− 0.44	+ 0,93	− 0.50	0 34 32.84	22 35 06.47	−1 59 26.37
ι Cephei	....	44 39.27	− 1.16	− 1.71	− 1.19	44 35.21	45 08.90	26.31
α Piscis Australis	....	50 02.05	0.19	1.94	− 0.57	50 03.23	50 36.74	26.49
α Ursæ Majoris, L. C	....	55 12.13	0.33	3.70	+ 1.07	55 17.23	55 50.44	26.79
ο Cephei	....	1 12 56.31	1.69	1.99	− 1,29	1 12 51.34	23 13 24.57	26.77
θ Piscium	....	20 57.12	0.57	1.04	− 0.50	20 57.09	21 30.63	26.46
γ Cephei	W.	33 45.03	2.56	4.47	− 2.19	33 35.81	33 69.15	26.66
α Cassiopeiæ	E.	2 32 46.48	1.78	0.76	+ 0.88	2 32 44.82	0 33 18.38	26.44
β Ceti	....	36 37.46	0.54	1.62	+ 0.52	36 39.06	37 12.43	26.63
ε Piscium	....	55 46.54	0.86	+ 1.00	+ 0.50	55 47.18	56 20.74	−1 59 26.44
Mean for $23^h\ 0^m$ local sidereal time								−1 59 26.44

Normal equations.

$$10 \quad \delta t - 0.74\,a - 6.61\,c = - 7.33$$
$$- 0.74\,\delta t + 16.27\,a - 19.42\,c = - 37.82 \qquad a = - 1^s.758$$
$$- 6.61\,\delta t - 19.42\,a + 45.50\,c = + 60.16 \qquad c = + 0^s.495$$

Fort Fred Steele, November 20, 1872.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
Piscium	E.	1 20 50.90	− 0.28	+ 2.63	+ 0.41	1 20 53.66	23 21 30.62	−1 59 23.04
γ Cephei..........	....	33 42.87	− 1.23	−11.30	+ 1.78	33 32 12	33 69.08	23.04
α Cassiopeiæ	W.	2 32 44.71	− 0.69	− 1.91	− 0.72	2 32 41.39	0 33 18.35	23.04
Mean for 0^h 0^m local sidereal time.....								−1 59 23.04

Normal equations.

$$+ 3 \quad \delta t + 2.38\,a + 3.65\,c = - 9.23$$
$$+ 2.38\,\delta t + 6.98\,a + 9.86\,c = - 27.20 \qquad a = - 4^s.452$$
$$+ 3.65\,\delta t + 9.86\,a + 23.73\,c = - 34.48 \qquad c = ..\ 0^s.403$$

Fort Fred Steele, November 21, 1872.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
α Aquarii..............	W.	23 58 30.00	−0.12	+ 2.64	−0.38	23 58 32.14	21 59 14.22	−1 59 17.92
32 Ursæ Majoris, L. C..	....	0 07 53.67	+0.15	+ 9.00	+0.91	0 08 03.73	22 08 45.72	18.01
π Aquarii..............	....	18 02.05	−0.18	+ 2.56	−0.38	18 04.05	18 46.16	17.89
9 Draconis (H.)	....	23 14.17	+0.60	+14.51	+1.59	23 30.87	24 12.70	18.17
γ Aquarii..............	....	28 04.42	−0.19	+ 2.64	−0.38	28 06.49	28 48.55	17.94
226 Cephei..............	....	29 30.59	−0.73	− 8.65	−1.51	29 19.70	29 61.29	18.41
ζ Pegasi...............	....	34 22.83	−0.16	+ 2.06	−0.38	34 24.35	35 06.45	17.90
π Aquarii..............	E.	45 13.18	−0.34	+ 3.03	+0.38	45 16.27	45 58.10	18.17
α Piscis Australis.....	....	49 50.12	−0.19	+ 4.27	+0.44	49 54.64	50 36.71	17.93
α Ursæ Majoris, L. C..	....	55 01.30	−0.28	+ 8.15	−0.81	55 08.36	55 50.56	17.80
α Pegasi...............	....	57 41.12	−0.50	+ 1.82	+0.39	57 42.83	58 25.07	17.76
ι Piscium	....	1 32 39.65	−0.44	+ 2.33	+0.38	1 32 41.92	23 33 24.29	17.63
γ Cephei...............	....	33 36.89	−2.02	− 9.86	+1.66	33 26.67	33 69.01	−1 59 17.66
Mean for 22^h 30^m local sidereal time.....								−1 59 17.94

Normal equations.

$$13 \quad \delta\,t - 8.89\,a + 5.09\,c = + 37.50$$
$$- 8.89\,\delta\,t + 39.24\,a - 15.28\,c = -158.95 \qquad a = -3^s.880$$
$$5.09\,\delta\,t - 15.28\,a + 72.72\,c = + 90.21 \qquad c = +0^s.375$$

Fort Fred Steele, November 22, 1872.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
9 Draconis, L. C	W.	0 23 18.72	+0.12	+8.75	0.00	0 23 27.59	22 24 12.81	−1 59 14.78
226 Cephei..............	....	29 20.84	−0.20	−5.22	0.00	29 15.42	29 61.20	14.22
ι Cephei...............	....	44 25.84	−0.30	−2.27	0.00	44 23.27	45 08.78	14.49
α Ursæ Majoris, L. C..	....	54 59.83	+0.05	+4.91	0.00	55 04.79	55 50.62	14.17
o Cephei...............	....	1 12 41.38	−0.20	−2.65	0.00	1 12 38.53	23 13 24.41	14.12
λ Draconis, L. C	....	22 55.62	+0.08	+6.37	0.00	23 02.07	23 48.22	13.85
γ Cephei...............	....	33 29.63	−0.25	−5.94	0.00	33 23.44	33 68.88	−1 59 14.56
Mean for 23^h 0^m local sidereal time.....								−1 59 14.31

Normal equations.

$$7 \quad \delta\,t - 1.69\,a - 4.12\,c = + 1.76$$
$$-1.69\,\delta\,t + 39.44\,a - 53.84\,c = - 91.94 \qquad a = -2^s.345$$
$$-4.12\,\delta\,t - 53.84\,a + 79.50\,c = +127.58 \qquad c = 0^s.000$$

Fort Fred Steele, November 22, 1872.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
κ Draconis......	W.	2 27 07.19	+0.11	+ 6.48	+0.67	2 27 14.45	0 28 00.46	−1 59 13.99
α Cassiopeiæ ...	....	32 33.67	−0.17	− 1.01	−0.40	32 32.09	33 18.30	13.79
21 Cassiopeiæ ...	....	36 38.17	−0.32	− 4.66	−0.83	36 32.36	37 18.18	14.18
32 Camelop'rdalis	E.	47 04.43	+0.57	+18.46	−2.19	47 21.27	48 07.25	14.02
ε Piscium	....	55 33.60	−0.08	+ 1.33	+0.23	55 35.08	56 20.71	14.37
38 Cassiopeiæ ...	....	3 21 05.61	−0.25	− 3.14	+0.65	3 21 02.87	1 21 48.97	−1 59 13.90
Mean for $0^h\ 30^m$ local sidereal time								−1 59 14.04

Normal equations.

$$6\ \delta t - 7.47\ a - 8.34\ c = 15.34$$
$$-7.47\ \delta t + 76.18\ a + 63.73\ c = -163.74 \qquad a = -2^s.340$$
$$-8.34\ \delta t + 63.73\ a + 129.86\ c = -119.46 \qquad c = +0^s.225$$

Fort Fred Steele, November 25, 1872.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
ι Cephei........	....	0 44 13.50	−1.12	−2.03	+0.45	0 44 10.80	22 45 08.60	−1 59 02.20
α Piscis Aust...	....	49 36.43	−0.18	+2.30	+0.21	49 38.76	50 36.64	02.12
α Urs.Maj.(L.C.)	....	54 48.09	+0.27	+4.39	−0.40	54 52.31	55 50.79	01.52
ο Cephei........	....	1 12 29.60	−1.17	−2.36	+0.48	1 12 26.55	23 13 24.28	02.27
θ Piscium	....	20 31.54	−0.40	+1.23	+0.19	20 32.56	21 30.56	02.00
ι Piscium	....	32 25.09	−0.35	+1.25	+0.19	32 26.18	33 24.25	01.93
Groom. 4163...	....	47 46.42	−1.38	−3.95	+0.66	47 41.75	48 40.24	01.51
μ Piscium	....	51 47.50	−0.37	+1.23	+0.19	51 48.55	52 46.63	01.92
α Andromedæ ..	....	2 00 50.32	−0.45	+0.54	+0.21	2 00 50.62	0 01 48.74	01.88
4 Draconis(L.C.)	....	04 03.82	+1.02	+8.92	−0.91	04 12.85	06 10.73	02.12
θ Ceti	....	3 16 41.14	−0.12	+1.63	−0.19	16 42.46	17 40.24	02.22
38 Cassiopieæ ...	....	20 54.96	−0.76	−2.80	−0.53	20 50.87	21 48.91	01.96
γ Piscium	....	23 42.39	−0.31	+0.98	−0.19	23 42.87	24 40.90	01.97
ο Piscium	....	37 42.31	−0.31	+1.17	−0.19	37 42.98	38 41.05	01.93
β Arietis	....	46 38.92	−0.44	+0.82	−0.20	46 39.10	47 37.27	−1 59 01.83
Mean for $0^h\ 0^m$ local sidereal time..								−1 59 01.96

Normal equations.

$$+15.00\ \delta t - 6.38\ a - 0.21\ c = +13.83$$
$$-6.38\ \delta t + 33.86\ a + 32.67\ c = -64.88 \qquad a = -2^s.090$$
$$-0.21\ \delta t + 32.67\ a + 72.51\ c = -54.83 \qquad c = +0^s.185$$

Salt Lake, November 5, 1872.

Name of star.	Clamp.	T	*b* B	*a* A	*c* C	T′	AR.	Δ T
		h. m. s.	*s.*	*s.*	*s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
ο Cephi..................	W.	23 16 01.13	−0.46	+ 5.09	+0.08	23 16 05.84	23 13 25.09	−0 02 40.75
θ Piscium	....	24 14.06	−0.07	− 2.52	+0.03	24 11.50	21 30.82	40.68
ω Piscium	....	36 07.59	−0.10	− 2.57	+0.03	36 04.95	33 24.40	40.55
γ Cephei.	....	36 40.31	−0.62	+11.31	+0.13	36 51.13	34 10.29	40.84
Groom. 4163	E.	51 14.14	−0.44	+ 8.44	−0.11	51 22.03	48 41.35	40.68
ω Piscium	....	55 30.21	−0.09	− 2.48	−0.03	55 27.61	52 46.80	40.81
α Andromedæ	....	0 04 30.97	−0.10	− 1.04	−0.03	0 04 29.80	0 01 48.96	40.84
γ Pegasi..................	....	09 24.11	−0.06	− 2.00	−0.03	09 22.02	06 41.26	40.76
ι Ceti	....	15 41.21	+0.02	− 3.39	−0.03	16 37.81	12 56.96	−0 02 40.85
Mean for $23^h\ 30^m$ local sidereal time..								−0 02 40.75

Normal equations.

$$+9.00\ \delta t - 2.49\ a + 1.27\ c = +13.12$$
$$-2.49\ \delta t + 13.78\ a - 8.53\ c = -60.68 \qquad a = -4^s.346.$$
$$+1.27\ \delta t - 8.53\ a + 45.30\ c = +38.70 \qquad c = +0^s.029$$

Salt Lake, November 19, 1872.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
θ Aquarii	W.	22 12 19.55	−0.15	−0.35	+0.04	22 12 19.09	22 10 06.54	−0 02 12.55
π Aquarii	....	20 59.27	−0.12	−0.29	+0.04	20 58.90	18 46.19	12.71
9 Draconis, L. C	....	26 27.29	+0.13	−1.71	−0.17	26 25.54	24 12.22	13.32
226 Cephei	....	32 13.80	−0.30	+1.05	+0.16	32 14.71	30 01.39	13.32
ζ Pegasi	....	37 19.55	−0.12	−0.24	+0.04	37 19.23	35 06.53	12.70
ι Cephei	E.	43 21.71	−0.21	+0.46	−0.09	43 21.87	45 08.89	12.98
λ Aquarii	....	48 11.40	−0.07	−0.35	−0.04	48 10.94	45 58.17	12.77
α Pegasi	....	23 00 38.24	−0.18	−0.21	−0.04	23 00 37.81	58 25.10	12.71
φ Aquarii	....	9 56.96	−0.14	−0.34	−0.04	09 56.44	23 07 43.74	12.70
ο Cephei	....	15 37.22	−0.46	+0.53	−0.10	15 37.19	13 24.50	−0 02 12.69
Mean, excluding 9 Draconis and 226 Cephei								−0 02 12.84
Mean for 22h. 30m. local sidereal time								−0 02 12.74

Normal equations.

$$\begin{array}{rrrl} +10.00\,\delta t & +\ 3.19\,a & -\ 5.25\,c & = -\ 0.17 \\ +\ 3.19\,\delta t & +24.29\,a & -\ 19.60\,c & = -11.45 \\ -\ 5.25\,\delta t & -19.60\,a & +\ 52.59\,c & = +10.57 \end{array} \qquad \begin{array}{l} \\ a = -\ 0^s.457. \\ c = +\ 0^s.042 \end{array}$$

Salt Lake, November 19, 1872.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
α Andromedæ	E.	0 04 01.72	−0.32	−0.06	−0.10	0 04 01.24	0 01 48.83	−0 02 12.41
γ Pegasi	....	08 53.98	−0.28	−0.11	−0.09	08 53.50	06 41.16	12.34
12 Ceti	....	25 46.17	−0.21	−0.18	−0.09	25 45.69	23 32.92	12.77
α Cassiopeiæ	W.	35 30.98	−0.73	+0.11	+0.16	35 30.52	33 18.27	12.25
β Ceti	....	39 25.21	−0.10	−0.22	+0.09	39 24.98	37 12.46	12.52
32 Camelopardalis, L. C	....	50 20.52	+0.92	−1.97	−0.88	50 18.59	48 06.17	12.42
ε Piscium	....	58 33.47	−0.13	−0.14	+0.09	58 33.29	56 20.73	−0 02 12.56
Mean for 0h 30m local sidereal time								−0 02 12.47

Normal equations.

$$\begin{array}{rrrl} +\ 7.00\,\delta t & +\ 10.43\,a & -\ 9.07\,c & = +\ 0.34 \\ +\ 10.43\,\delta t & +\ 66.14\,a & -\ 78.83\,c & = -17.81 \\ -\ 9.07\,\delta t & -\ 78.83\,a & +103.96\,c & = +\ 23.82 \end{array} \qquad \begin{array}{l} \\ a = -\ 0^s.246 \\ c = +\ 0^s.091 \end{array}$$

Salt Lake, November 20, 1872.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	Δ T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
π Aquarii	W.	22 20 56.45	−0.17	−0.27	+0.03	22 20 56.04	22 18 46.18	−0 02 09.86
9 Draconis, L. C	....	26 23.86	+0.40	−1.60	−0.11	26 22.55	24 12.32	10.23
226 Cephei	....	32 11.20	−0.66	+0.98	+0.11	32 11.63	30 01.31	10.32
ξ Pegasi	....	37 16.75	−0.16	−0.22	+0.03	37 16.40	35 06.52	09.88
λ Aquarii	....	48 08.30	−0.17	−0.33	+0.03	48 07.83	45 58.16	09.67
ο Cephei	E.	23 15 34.54	−0.62	+0.50	−0.07	23 15 34.35	23 13 24.45	09.90
θ Piscium	....	23 41.23	−0.22	−0.24	−0.03	23 40.74	21 30.67	10.07
γ Cephei	....	36 19.15	−0.97	+1.11	−0.12	36 19.17	34 09.22	09.95
ι Piscium	....	35 34.79	−0.22	−0.25	−0.03	35 34.29	33 24.26	−0 02 10.03
Mean for 23h 0m local sidereal time								−0 02 09.99

Normal equations.

$$\begin{array}{rrrl} +\ 9.00\,\delta t & +\ 0.77\,a & -\ 6.19\,c & = -\ 0.39 \\ +\ 0.77\,\delta t & +\ 29.42\,a & -\ 9.54\,c & = -\ 12.82 \\ -\ 6.19\,\delta t & -\ 9.54\,a & +\ 65.34\,c & = +\ 5.77 \end{array} \qquad \begin{array}{l} \\ a = -\ 0^s.427 \\ c = +\ 0^s.027 \end{array}$$

Salt Lake, November 20, 1872.

Name of star.	Clamp.	T	bB	aA	cC	T′	AR	ΔT
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
α Andromedæ	E.	0 03 59.26	− 0.28	− 0.08	− 0.10	0 03 58.80	0 01 48.82	−00 02 9.98
γ Pegasi	....	08 51.73	− 0.22	− 0.16	− 0.09	08 51.26	06 41.16	10.10
ι Ceti	....	15 07.28	− 0.14	− 0.27	− 0.09	15 06.78	12 56.84	09.94
12 Ceti	W.	25 43.15	− 0.12	− 0.25	+ 0.09	25 42.87	23 32.91	09.96
α Cassiopeiæ	....	35 28.16	− 0.22	+ 0.16	+ 0.15	35 28.25	33 18.25	10.00
β Ceti	....	39 22.79	− 0.06	− 0.32	+ 0.09	39 22.50	37 12.45	−0 02 10.05
Mean for 0^h 0^m local sidereal time								−0 02 10.00

Normal equations.

$$+6.00\,\delta t + 2.64\,a + 0.66\,c = -0.91$$
$$+2.64\,\delta t + 2.43\,a - 0.68\,c = -0.91 \qquad a = -0^s.351$$
$$+0.66\,\delta t - 0.68\,a + 8.72\,c = +0.99 \qquad c = +0^s.086$$

Salt Lake, November 21, 1872.

Name of star.	Clamp.	T	bB	aA	cC	T′	AR	T
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m s.
ξ Pegasi	W.	22 37 14.76	− 0.22	− 0.35	+ 0.14	22 37 14.33	22 35 06.51	−0 02 07.82
ι Cephei	....	47 16.32	− 0.59	+ 0.68	+ 0.33	47 16.74	45 08.80	07.94
α Pegasi	....	23 00 33 24	− 0.25	− 0.30	+ 0.14	23 00 32.83	58 25.08	07.75
φ Aquarii	....	09 52.01	− 0.16	− 0.50	+ 0.14	09 51.49	23 07 43.72	07.77
ο Cephei	E.	15 32.32	− 0.46	+ 0.78	− 0.35	15 32.29	13 24.41	07.88
Piscium	....	23 38.99	− 0.16	− 0.38	− 0.14	23 38.31	21 30.66	07.65
ι Piscium	....	35 32.38	− 0.16	− 0.39	− 0.14	35 31.69	33 24.25	07.44
γ Cephei	....	36 16.64	− 0.72	+ 1.73	− 0.61	36 17.04	34 09.14	−0 02 07.90
Mean for 23^h 0^m local sidereal time								−0 02 07.77

Normal equations.

$$+8.00\,\delta t - 1.92\,a - 3.54\,c = +2.63$$
$$-1.92\,\delta t + 10.92\,a + 12.78\,c = -5.07 \qquad a = -0^s.664$$
$$-3.54\,\delta t + 12.78\,a + 37.43 \quad - 4.19 \qquad c = +0^s.137$$

Salt Lake, November 21, 1872.

Name of star.	Clamp.	T	bB	aA	cC	T′	AR.	ΔT
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
α Andromedæ	E.	0 03 56.88	− 0.34	− 0.13	− 0.02	0 03 56.39	0 01 48.81	−0 02 07.58
γ Pegasi	....	08 49.33	− 0.28	− 0.24	− 0.02	08 48.79	06 41.14	07.65
ι Ceti	....	15 05.16	− 0.18	− 0.42	− 0.02	15 04.54	12 56.76	07.78
α Cassiopeiæ	W.	35 25.70	− 0.38	+ 0.25	+ 0.03	35 25.60	33 18.23	07.37
β Ceti	....	39 20.53	− 0.09	− 0.49	+ 0.02	39 19.97	37 12.44	07.53
32 Camelop.,L.C.	....	50 17.64	+ 0.90	− 4.33	− 0.18	50 14.03	48 06.53	07.50
ε Piscium	....	58 28.78	− 0.14	− 0.30	+ 0.02	58 28.36	56 20.72	−0 02 07.64
Mean for 0^h 0^m local sidereal time								−0 02 07.58

Normal equations.

$$+7.00\,\delta t + 10.47\,a - 9.08\,c = -2.88$$
$$+10.47\,\delta t + 66.21\,a - 78.92\,c = -32.53 \qquad a = -0^s.541$$
$$-9.08\,\delta t - 78.92\,a + 104.02\,c = +40.66 \qquad c = +0^s.018$$

Salt Lake, November 22, 1872.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	ΔT
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
π Aquarii	W.	22 20 52.18	− 0.22	− 0.30	+ 0.03	22 20 51.69	22 18 46.17	−0 02 05.52
226 Cephei		32 06.86	− 1.02	+ 1.08	+ 0.12	32 07.04	30 01.13	05.91
ζ Pegasi		37 12.47	− 0.27	− 0.25	+ 0.03	37 11.98	35 06.50	05.48
ι Cephei		47 13.93	− 0.59	+ 0.48	+ 0.07	47 13.89	45 08.75	05.14
λ Aquarii		48 04.16	− 0.15	− 0.36	+ 0.03	48 03.68	45 58.14	05.54
α Pegasi	E.	23 00 30.98	− 0.07	− 0.21	− 0.03	23 00 30.67	58 25.07	05.60
φ Aquarii		09 49.85	− 0.01	− 0.35	− 0.03	09 49.46	23 07 43.72	05.74
ο Cephei		15 29.60	+ 0.07	+ 0.55	− 0.08	15 30.14	13 24.36	05.78
θ Piscium		23 36.69	+ 0.04	− 0.27	− 0.03	23 36.43	21 30.64	05.79
γ Cephei		36 13.19	+ 0.18	+ 1.23	− 0.13	36 14.47	34 09.05	−0 02 05.42
Mean for $23^h\ 0^m$ local sidereal time								−0 02 05.59

Normal equations.

$$+10.00\,\delta t - 3.39\,a - 0.63\,c = -4.34$$
$$-3.39\,\delta t + 16.81\,a + 3.15\,c = -5.87 \qquad a = -0^s.473$$
$$-0.63\,\delta t + 3.15\,a + 54.55\,c = +0.64 \qquad c = +0^s.032$$

Salt Lake, November 25, 1872.

Name of star.	Clamp.	T	b B	a A	c C	T′	AR.	ΔT
		h. m. s.	s.	s.	s.	h. m. s.	h. m. s.	h. m. s.
226 Cephei	W.	22 31 58.88	+0.06	+0.68	+0.21	22 31 59.83	22 30 00.88	−0 01 58.95
ζ Pegasi		37 05.63	+0.01	−0.15	+0.05	37 05.54	35 06.46	59.08
ι Cephei		47 06.96	+0.06	+0.30	+0.12	47 07.44	45 08.61	58.83
λ Aquarii		47 57.30	+0.04	−0.23	+0.05	47 57.16	45 58.11	59.05
α Pegasi		23 00 24.06	+0.02	−0.13	+0.05	23 00 24.00	58 25.03	58.97
φ Aquarii	E.	09 42.89	+0.05	−0.22	−0.05	09 42.67	23 07 43.70	58.97
ο Cephei		15 22.82	+0.14	+0.35	−0.13	15 23.18	13 24.22	58.96
θ Piscium		23 29.51	+0.04	−0.17	−0.05	23 29.33	21 30.61	58.72
ι Piscium		35 23.34	+0.04	−0.18	−0.05	35 23.15	33 24.21	58.94
γ Cephei		36 07.12	+0.14	+0.78	−0.23	36 07.81	34 08.82	−0 01 58.99
Mean for $23^h\ 0^m$ local sidereal time								−0 01 58.95

Normal equations.

$$+10.00\,\delta t - 3.44\,a - 0.55\,c = +1.53$$
$$-3.44\,\delta t + 16.75\,a + 2.85\,c = -5.03 \qquad a = -0^s.298$$
$$-0.55\,\delta t + 2.85\,a + 54.55\,c = +1.96 \qquad c = +0^s.052$$

Salt Lake chronometer.

NEGUS 1511.

1872.	Local sidereal time.	Correction of chronometer.	Adopted hourly rates.
	h.	m. s.	s.
November 5	23.5	−2 40.75	0.017
November 7	22.5	39.96	0.026
November 19	23.5	12.61	0.101
November 20	23.5	10.00	0.103
November 21	23.5	07.68	0.092
November 22	23.0	−2 05.59	0.090
November 25	23.0	−1 58.95	0.112
November 26	23.0	55.78	0.132

Fort Fred Steele chronometer.

NEGUS 1499.

1872.	Local sidereal time.	Correction of chronometer.	Adopted hourly rates.
	h.	h. m. s.	s.
November 5	23.0	—2 00 22.70	0.129
November 7	22.5	16.52	0.140
November 19	23.0	—1 59 26.54	0.150
November 20	24.0	23.04	0.180
November 21	22.5	17.93	0.181
November 22	23.5	14.16	0.161
November 25	0.0	59 01.96	0.201
November 26	22.5	—1 58 56.40	0.232

NOVEMBER 5, 1872.

Signals sent from Salt Lake.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
1 03 40.4	22 46 10.7	1 05 30.7	22 48 01.1	1 07 20.9	22 49 51.1
50.4	20.8	40.7	11.1	31.2	50 01.4
04 00.2	30.6	50.6	20.9	41.2	11.4
10.2	40.6	6 01.0	31.1	51.1	21.2
20.3	50.7	10.6	40.9	08 00.7	31.1
30.7	47 01.1	20.7	51.0	11.0	41.1
40.6	10.9	30.9	49 01.1	21.0	51.3
50.4	20.8	40.9	11.1	31.4	51 01.7
05 00.5	30.8	50.7	21.1	41.0	11.3
10.4	40.7	07 00.7	31.0		
20.4	50.8	10.7	41.1	Mean, 1 6 10.71	22 48 41.02

Signals sent from Fort Fred Steele.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
1 10 06.1	22 52 36.3	1 12 06.7	22 54 37.1	1 14 07.5	22 56 37.9
17.1	47.3	17.3	47.7	16.8	47.1
27.6	58.0	27.0	57.4	27.7	58.1
35.8	53 06.3	36.1	55 06.4	36.6	57 07.0
46.0	16.3	47.9	18.2	47.2	17.8
56.1	26.3	56.6	27.0	57.2	27.8
11 06.5	36.8	13 07.3	37.8	15 07.5	38.0
17.0	47.3	17.1	47.4	17.2	47.6
26.4	56.9	27.0	57.4	27.4	57.9
36.1	54 06.3	36.8	56 07.2		
46.7	16.1	47.2	17.7	Mean, 1 12 46.88	22 55 17.23
56.6	27.0	57.0	27.3		

NOVEMBER 19, 1872.

Signals sent from Salt Lake.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
2 00 28.3	23 43 27.0	2 02 18.0	23 45 16.7	2 04 08.3	23 47 07.1
38.1	36.9	28.2	26.9	18.3	17.1
48.2	46.9	38.2	36.9	28.6	27.1
58.0	56.8	48.3	47.1	38.7	37.2
01 08.2	44 06.9	58.2	56.9	48.7	47.2
17.9	16.6	03 08.1	46 06.9	58.7	57.2
27.8	26.3	18.3	17.0	05 08.6	48 07.2
38.2	36.9	28.3	26.9	18.7	17.3
48.3	47.0	38.3	37.1	28.6	27.2
58.1	56.8	48.7	47.2		
02 07.9	45 06.7	58.3	57.1	Mean, 2 02 58.30	23 45 56.97

Signals sent from Fort Fred Steele.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
2 07 33.8	23 50 32.6	2 09 24.6	23 52 23.3	2 11 14.6	23 54 12.3
43.5	42.2	34.2	33.0	24.9	23.8
53.6	52.3	43.7	42.5	34.8	33.7
08 03.2	51 02.0	54.1	52.9	43.8	42.6
14.0	12.9	10 03.2	53 01.8	53.3	53.1
24.7	23.3	14.5	13.2	12 03.5	55 02.1
34.4	33.1	24.6	23.3	14.8	13.5
43.7	42.3	34.5	33.2	25.0	23.8
53.7	52.3	44.0	42.8	34.9	33.8
09 03.4	52 02.1	54.5	53.1		
14.6	12.2	11 03.3	54 02.0	Mean, 2 10 03.11	23 53 01.84

NOVEMBER 20, 1872.

Signals sent from Salt Lake.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
2 55 17.7	23 38 16.9	1 57 07.5	23 40 06.8	1 58 57.8	23 41 57.0
27.3	26.5	17.5	16.8	59 07.8	42 07.0
37.6	36.9	27.8	27.0	17.8	17.0
47.6	46.9	37.8	37.1	28.0	27.2
57.1	56.2	47.8	47.1	38.1	37.3
56 07.1	39 06.3	57.8	56.9	48.2	47.4
17.3	16.5	58 07.6	41 06.9	58.0	57.2
27.6	26.9	17.5	16.8	2 00 08.0	43 07.1
37.8	37.0	28.0	27.1	17.8	17.0
47.8	47.0	38.1	37.2		
57.5	56.8	47.7	47.1	Mean, 1 57 47.71	23 40 46.93

Signals sent from Fort Fred Steele.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer
h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
2 01 19.5	23 44 18.8	2 03 10.5	23 46 09.9	2 05 01.1	23 48 00.3
30.5	30.0	20.3	19.7	11.2	10.2
40.7	40.0	30.7	30.0	20.8	20.1
50.7	50.0	41.0	40.2	30.8	30.1
02 00.3	59.7	50.8	50.1	40.9	40.1
10.4	45 09.7	59.9	59.2	51.2	50.4
19.7	19.0	04 10.3	47 09.6	06 01.2	49 00.5
30.5	29.9	20.2	19.5	11.0	10.2
41.0	40.2	30.3	29.6	21.0	20.2
50.8	50.1	41.1	40.2		
03 00.4	59.8	51.3	50.6	Mean, 2 03 50.65	23 46 49.93

NOVEMBER 21, 1872.

Signals sent from Salt Lake.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
2 00 34.5	23 43 36.9	2 02 24.8	23 45 27.1	2 04 14.9	23 47 17.3
44.2	46.8	34.6	37.0	25.1	27.7
54.1	56.7	44.4	46.9	34.9	37.3
01 04.2	44 06.8	54.5	56.9	44.7	47.1
14.5	17.0	03 04.5	46 07.0	54.7	57.1
24.6	27.1	14.8	17.1	05 04.9	48 07.4
34.4	36.9	25.1	27.6	15.1	17.6
44.3	46.8	34.6	37.1	25.3	27.8
54.3	56.8	44.6	47.1	35.1	37.8
02 04.3	45 06.8	54.6	57.0		
14.6	17.0	04 04.8	47 07.1	Mean, 2 03 04.65	23 46 07.12

Signals sent from Fort Fred Steele.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
2 06 45.2	23 49 47.8	2 08 55.5	23 51 58.1	2 11 05.9	23 54 08.5
56.6	59.2	09 05.8	52 08.3	15.1	17.5
07 05.1	50 07.6	....	....	25.6	28.1
14.9	17.5	....	....	35.0	37.5
25.2	27.5	34.9	37.5	45.7	48.2
34.5	37.0	....	....	56.1	58.5
45.4	48.0	....	....	12 06.2	55 08.5
55.5	58.1	10	53	15.6	18.1
08 05.6	51 08.1	....	....	25.5	28.1
....	....	....	....	35.0	37.6
....	....	34.8	37.3	45.7	48.2
34.4	37.0	45.5	48.0		
45.2	47.5	55.9	58.3	Mean, 2 09 49.69	23 52 52.20

NOVEMBER 22, 1872.

Signals sent from Salt Lake.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
1 57 23.1	23 40 27.1	1 59 13.1	23 42 17.1	2 01 03.3	23 44 07.2
33.0	37.0	23.1	27.1	13.5	17.3
42.9	46.9	33.0	36.9	23.4	27.2
53.1	57.1	43.0	46.9	33.3	37.1
58 02.6	41 06.6	53.0	56.9	43.3	47.2
12.9	16.9	2 00 03.1	43 07.1	53.1	57.1
22.9	26.9	13.1	17.1	02 03.4	45 07.2
32.8	36.8	23.1	27.1	13.7	17.7
42.9	46.9	33.0	37.0	23.6	27.4
52.8	56.8	43.1	47.0		
59 03.0	42 06.9	53.1	57.0	Mean, 1 59 53.11	23 42 57.05

Signals sent from Fort Fred Steele.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
2 12 00.1	23 55 04.1	2 13 50.6	23 56 54.7	2 15 40.4	23 58 44.3
10.8	14.9	14 00.3	57 04.3	50.9	54.9
20.8	24.9	10.8	14.9	16 00.6	59 04.5
31.0	35.0	20.7	24.8	10.9	14.8
40.3	44.2	30.7	34.7	20.8	24.9
50.6	54.7	40.4	44.3	30.9	34.9
13 00.0	56 04.0	50.9	54.9	40.5	44.6
10.3	14.2	15 00.9	58 04.9	51.0	55.0
20.6	24.7	10.5	14.3	17 01.0	24 00 05.0
31.0	35.0	20.6	24.8		
40.4	44.3	30.9	34.9	Mean, 2 14 30.65	23 57 34.66

NOVEMBER 25, 1872.

Signals sent from Salt Lake.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*	*h. m. s.*
2 36 24.0	0 19 33.1	2 38 14.4	0 21 23.5	2 40 04.7	0 23 13.9
34.3	43.3	24.2	33.3	14.7	23.9
44.8	54.0	34.5	43.8	24.6	33.9
54.5	20 03.8	45.0	54.2	34.9	44.0
37 04.3	13.4	54.8	22 04.0	45.1	54.1
14.2	23.3	39 04.6	13.9	55.0	24 04.2
24.1	33.3	14.7	23.9	41 04.8	14.1
34.3	43.5	24.3	33.3	14.8	24.0
44.8	54.0	34.7	44.0	24.8	34.0
54.7	21 04.0	44.8	54.1		
38 04.4	13.6	54.8	23 04.1	Mean, 2 38 54.60	0 32 03.79

Signals sent from Fort Fred Steele.

Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.	Ft. Fred Steele chronometer.	Salt Lake chronometer.
h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
2 48 54.8	0 32 04.1	2 50 25.5	0 33 34.9	2 51 54.9	0 35 04.2
49 05.2	14.2	34.8	44.1	52 05.6	15.0
15.7	25.1	45.3	54.6	15.9	25.2
25.7	35.1	54.9	34 04.2	25.7	35.1
35.2	44.5	51 05.5	14.8	34.7	44.1
45.3	54.7	15.7	25.1	45.6	55.0
54.7	33 04.0	25.7	35.1	55.3	36 04.7
50 05.1	14.4	35.2	44.6		
15.7	25.1	45.4	54.9	Mean, 2 50 55.32	0 34 04.67

Signals sent from—	Recorded at—	Mean of signals sent and received.	Time corrections.	Corrected time.	Difference of longitude.	time.	Means.
Nov. 5, 1872.		h. m. s.	h. m. s.	h. m. s.	h. m. s.	s.	s.
Salt Lake	Ft. Fred Steele.	1 06 10.71	—2 00 22.69	23 05 48.02			
	Salt Lake......	22 48 41.02	—0 02 40.76	22 46 00.26	0 19 47.76		
Fort Fred Steele	Ft. Fred Steele.	1 12 46.88	—2 00 22.67	23 12 24.21			
	Salt Lake......	22 55 17.23	—0 02 40.76	22 52 36.47	47.74	0.02	47.750
Nov. 19, 1872.							
Salt Lake	Ft. Fred Steele.	2 02 58.30	—1 59 26.39	0 03 31.91			
	Salt Lake......	23 45 56.97	—0 02 12.59	23 43 44.38	47.53		
Fort Fred Steele	Ft. Fred Steele.	2 10 03.11	—1 59 26.37	0 10 36.74			
	Salt Lake......	23 53 01.84	—0 02 12.58	23 50 49.26	47.48	0.05	47.505
Nov. 20, 1872.							
Salt Lake	Ft. Fred Steele.	1 57 47.71	—1 59 23.03	23 58 24.68			
	Salt Lake......	23 40 46.93	—0 02 09.98	23 38 36.95	47.73		
Fort Fred Steele	Ft. Fred Steele.	2 03 50.65	—1 59 23.01	0 04 27.64			
	Salt Lake......	23 46 49.93	—0 02 09.97	23 44 39.96	47.68	0.05	47.705
Nov. 21, 1872.							
Salt Lake	Ft. Fred Steele.	2 03 04.65	—1 59 17.64	0 03 47.01			
	Salt Lake......	23 46 07.12	—0 02 07.66	23 43 59.46	47.55		
Fort Fred Steele	Ft. Fred Steele.	2 09 49.69	—1 59 17.62	0 10 32.07			
	Salt Lake......	23 52 52.20	—0 02 07.65	23 50 44.55	47.52	0.03	47.535
Nov. 22, 1872.							
Salt Lake	Ft. Fred Steele.	1 59 53.11	—1 59 14.08	0 00 39.03			
	Salt Lake	23 42 57.05	—0 02 05.53	23 40 51.52	47.51		
Fort Fred Steele	Ft. Fred Steele.	2 14 30.65	—1 59 14.04	0 15 16.61			
	Salt Lake......	23 57 34.66	—0 02 05.51	23 55 29.15	47.46	0.05	47.485
Nov. 25, 1872.							
Salt Lake	Ft. Fred Steele.	2 38 54.60*	—1 59 01.83	0 39 52.77			
	Salt Lake......	0 22 03.79	—0 01 58.80	0 20 04.99	47.78		
Fort Fred Steele	Ft. Fred Steele.	2 50 55.32	—1 59 01.79	0 51 53.53			
	Salt Lake......	0 34 04.67	—0 01 58.78	0 32 05.89	47.64	0.14	47.710

longitude: Fort Fred Steele, east of Salt Lake, $0^h\ 19^m\ 47^s.612 \pm 0^s.034$.

Observations and computations for latitude of Fort Fred Steele, Wyo.

NOVEMBER 3, 1872.

Number of star.	Micrometer-readings.	Level.		Remarks.	Half sum of declination.	Corrections.			Latitude.
		N.	S.			Micrometer and reference.	Level.	Meridian.	
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
8212	4 1.5	9.5	32.5						
8237	26 32.2	36.0	6.0	....	41 35 6.2	+11 33.3	+ 1.8	....	41 46 41.3
8256	35 67.0	20.0	21.0						
8322	29 63.5	23.0	17.5	....	49 47.4	− 3 7.6	+ 1.2	....	41.0
8284	5 43.0	20.0	21.0						
8322	29 63.5	23.0	17.5	....	34 6.3	+12 32.3	+ 2.9	....	41.5
8330	26 82.0	23.0	17.5						
4	20 7.0	23.0	18.0	....	43 11.3	+ 3 29.8	+ 2.9	....	44.0
51	25 46.5	24.5	19.0						
58	12 23.5	28.5	14.0	....	39 44.2	+ 6 51.2	+ 5.5	....	40.9
101	2 43.3	19.5	20.0						
114	34 17.0	14.0	26.0	....	30 15.0	+16 26.4	− 3.4	....	38.0
gr.96	9 2.2				50 6.1	− 3 29.9	+ 2.0	....	38.2
146	11 5.0	7.0	32.0	....	49 3.7	− 2 26.8	+ 2.0	....	38.9
153	26 75.6				40 56.5	+ 5 41.3	+ 2.0	....	39.8
166	15 77.5	35.5	3.5						
215	36 99.5	25.5	13.5						
239	11 5.0	15.5	25.5	....	60 5.8	−13 26.4	+ 0.6	....	40.0
250	0 19.0	25.5	13.5						
253	34 10.0	15.0	27.5	....	29 6.0	+17 33.9	− 0.1	....	39.8
282	13 10.0	....	....	....	39 59.5	+ 6 41.2	− 0.1	....	40.6
299	10 83.2	24.5	19.0						
314	26 98.0	15.5	28.0	....	38 21.1	+ 8 21.9	− 1.8	....	41.2
330	12 58.0	20.5	22.0						
343	15 96.0	25.0	18.0	....	48 23.5	− 1 45.1	+ 1.5	....	39.9

NOVEMBER 4, 1872.

Number of star.	Micrometer-readings.	Level N.	Level S.	Remarks.	Half sum of declination.	Micrometer and reference.	Level.	Meridian.	Latitude.
8024	6 48.0	28.0	23.0						
8032	21 53.0	8.0	44.0	....	41 54 37.0	− 7 47.7	− 8.6	....	41 46 40.7
8083	3 99.0	26.0	26.0						
8097	30 91.5	8.5	43.5	....	60 46.7	−13 56.8	−11.4	....	38.5
8212	4 96.0	24.0	27.0						
8223	22 13.0	9.0	43.0	....	37 59.0	+ 8 53.6	−10.1	....	42.5
8237	27 65.0	10.0	42.0	....	35 6.3	+11 45.2	− 9.7	....	41.8
8256	35 37.0	6.0	45.0						
8322	29 58.5	30.0	20.5	....	49 47.5	− 2 59.8	− 8.1	....	39.6
8330	26 82.4	30.0	20.5						
4	19 78.5	6.0	42.0	....	43 11.4	+ 3 38.8	− 7.3	....	42.9
153	25 68.0	19.0	33.0						
166	14 28.5	10.0	42.5	....	40 56.7	+ 5 54.2	−12.7	....	38.2
215	37 6.0	18.0	35.0						
239	11 37.5	18.0	35.0	....	60 6.0	−13 18.3	− 9.3	....	38.4
250	0 27.0	15.0	39.5						
282	13 50.2	17.0	40.0	....	39 59.6	+ 6 51.3	−13.1	....	37.8
299	9 71.0	28.0	28.0						
314	26 4.5	8.0	48.0	....	38 21.3	+ 8 27.7	−11.0	....	38.0
330	12 70.0	48.0	8.0						
343	15 68.0	....	....	(*)	48 23.7	− 1 32.6	−11.0	....	40.1

* Level could not be read on reversal.

Observations and computations for latitude of Fort Fred Steele, Wyo.—Continued.

NOVEMBER 4, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
409	15 86.0	....	....						
441	24 98.0	....	....	....	41 42 6.5	− 4 43.5	−11.0	....	41 46 39.0
480	12 15.5	14.0	40.0						
501	20 7.0	19.0	35.0	....	42 45.4	+ 4 6.0	−11.5	....	39.9
558	24 68.0	14.0	42.0						
569	38 78.5	....	....		44 18.4	+ 2 32.0	−11.0	....	39.7
610	22 54.0	....	....		39 10.3	+ 7 43.7	−10.5	....	43.5
620	10 70.2	11.0	44.0	....	54 8.1	− 7 14.1	−10.4	....	43.6
686	7 62.0	25.0	30.0						
707	24 67.0								
731	11 99.0	38.0	18.0						
786	12 2.0	0.0	56.0	....	46 50.9	− 0 0.9	− 9.9	....	40.1

NOVEMBER 6, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
7623	17 46.7	30.0	32.0						
7636	2 70.5	11.0	51.0	....	41 54 32.0	− 7 38.8	−11.5	....	41 46 41.7
7699	17 50.2	16.0	47.0						
7712	19 58.0	48.0	15.5	....	47 43.3	− 1 4.6	+ 0.4	....	39.1
7754	12 67.2	30.5	31.5	....	57 6.0	−10 26.9	+ 1.2	....	40.3
7778	0 94.5	....	....	....	63 10.5	−16 31.5	+ 1.2	....	40.2
7798	22 84.0	33.5	28.0	Must be 32t					
7815	18 74.2	....	....	(†)					
7843	16 74.8	....	....	....	45 36.0	+ 1 2.0	+ 1.2	....	39.2
7880	16 61.2	21.0	40.0						
7894	19 64.0	35.0	26.0	....	45 8.4	+ 1 34.1	− 2.7	....	39.8
7962	28 31.8	29.0	34.0	(‡)	57 40.5	−10 50.4	−10.4	....	39.7
7972	7 39.0	15.0	48.0	....	47 1.5	− 0 21.1	− 2.0	....	38.4
7994	8 7.0	45.0	19.0						
8024	6 75.8	35.5	28.0	....	54 10.8	− 7 27.5	− 3.4	....	39.9
8083	4 22.0	34.5	29.0	....	60 46.9	−14 5.1	− 4.0	....	37.8
8091	21 15.5								
8097	31 41.0	22.0	42.0						
8212	4 89.7	33.0	29.0						
8237	27 45.0	17.0	45.0	....	35 6.5	+11 41.0	− 6.6	....	40.9
				Releveled.					
8256	36 35.2	31.5	31.5	....	51 15.9	− 4 29.7	− 6.6	....	39.6
8284	6 13.5	23.0	39.0	....	34 6.7	+12 36.0	− 4.4	....	38.3
8322	30 46.0	....	....	....	49 47.7	+ 6 59.0	− 4.4	....	42.3
8330	27 67.5	23.0	40.0						
4	20 95.7	42.0	20.0	....	43 11.6	+ 3 28.8	+ 1.3	....	41.7
51	25 54.2	32.0	31.0						
58	12 57.2	51.0	12.0	....	39 44.5	+ 6 43.1	+12.6	....	40.2
101	2 41.0	28.0	35.5						
114	33 80.0	57.5	6.0	....	30 15.5	+16 15.6	+12.1	....	43.2
146	9 83.8	....	....	....	49 4.1	− 2 24.0	− 0.2	....	39.9
153	25 50.3	31.0	31.0	....	40 57.0	+ 5 42.9	− 0.3	....	39.6
166	14 47.0	31.0	32.0						
215	36 61.0	35.0	27.5						
239	10 62.0	27.5	36.0	....	60 6.3	−13 27.8	− 0.3	....	38.2
253	33 65.2	30.0	33.5	....	48 10.6	− 1 31.9	+ 1.1	....	39.8
282	12 58.8	35.0	27.5	....	59 3.8	−12 26.6	+ 4.1	....	41.3

† No level taken. ‡ Level doubtful.

Observations and computations for latitude of Fort Fred Steele, Wyo.—Continued.

NOVEMBER 6, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
299	10 43.0	29.0	35.0						
314	26 30.0	48.0	16.0	....	41 38 21.6	+ 8 13.2	+ 7.1	....	41 46 41.9
330	12 32.5	36.0	27.5						
343	15 87.0	37.0	27.0	....	48 24.0	− 1 50.2	+ 5.1	....	38.9
409	16 9.8	38.0	25.0						
441	24 66.2	38.5	24.5	....	42 6.8	+ 4 26.2	+ 7.4	....	40.4
480	13 65.0	25.0	36.5						
501	20 98.5	50.5	11.0	....	42 45.8	+ 3 48.0	+ 7.7	....	41.5
558	24 39.0	46.0	17.5						
569	19 93.0	23.5	40.0	Clondy....	44 19.1	+ 2 18.6	+ 3.3	....	41.0

NOVEMBER 8, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
8212	3 65.0	23.5	23.0		41 37 59.4	+ 8 33.5	+ 9.4	....	41 46 42.3
8223	20 17.3	40.0	6.0						
8237	25 74.7	....	....	....	35 6.7	+11 26.8	+ 9.4	....	42.9
8256	35 85.5	26.0	19.5		49 47.8	− 3 12.0	+ 5.4	....	41.2
8284	5 58.0	....	....		34 6.9	+12 28.9	+ 5.4	....	41.2
8322	29 67.7	29.0	16.0						
8330	26 88.0	29.0	16.0						
4	20 40.0	32.0	14.0	....	43 11.8	+ 3 21.4	+ 8.6	....	41.8
51	24 86.0	24.0	22.0						
58	11 87.0	41.0	4.0	....	39 45.0	+ 6 43.7	+10.7	....	39.4
101	1 77.0	19.0	27.0						
114	33 37.0	32.0	13.0	....	30 15.8	+16 22.1	+ 3.0	....	40.9
Gr.96	8 57.8	29.0	16.5		50 6.9	− 3 33.3	+ 5.7	....	39.3
146	10 59.0	....	....		49 4.4	− 2 30.7	+ 5.7	....	39.4
153	26 26.0	....	....		40 57.4	+ 5 36.2	+ 5.7	....	39.3
166	15 44.0	27.0	18.5						
215	37 46.0	16.0	30.0						
239	11 30.0	39.0	7.0	....	60 6.6	−13 33.0	+ 4.9	....	38.5
250	0 63.6	17.0	28.5						
253	34 29.0	40.0	6.0		29 6.9	+17 26.2	+ 6.2	....	39.3
282	13 35.6	....	....		40 0.4	+ 6 35.5	+ 6.2	....	42.1
299	7 94.5	21.0	25.0						
314	24 11.5	18.0	28.0	(*)	38 21.9	+ 8 22.6	− 3.8	....	40.7
330	12 27.0	30.0	15.0						
343	15 93.5	34.0	12.0	....	48 24.5	− 1 53.9	+10.1	....	40.7
409	16 5.0	29.0	18.0						
441	24 48.0	42.0	5.0	....	42 7.2	+ 4 22.0	+13.2	....	42.4
480	12 3.0	13.5	33.5						
501	19 42.5	44.5	2.5	....	42 46.1	+ 3 49.8	+ 6.0	....	41.9
558	23 81.0	25.0	22.0						
569	19 51.0	32.5	14.0	....	44 19.5	+ 2 13.6	+ 5.9	....	39.0
588	38 76.5	....	....		27 5.7	+19 26.4	+ 7.7	....	39.8
610	22 32.3	27.0	19.0	....	39 11.0	+ 7 22.5	+ 7.7	....	41.2
665	1 23.7								
686	8 8.5	34.0	14.0						
915	41 49.0	38.0	9.0						
962	27 18.2	22.0	25.0	....	53 58.1	− 7 24.7	+ 6.2	....	39.6

* Level doubtful.

Observations and computations for latitude of Fort Fred Steele, Wyo.—Continued.

NOVEMBER 8, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
1007	14 97.2	27.0	19.0		41 45 20.1	+ 1 10.2	+ 8.5	....	41 46 38.8
1011	22 25.7	....	....		41 33.3	+ 4 56.6	+ 8.5	....	38.4
1017	12 71.5	35.0	11.5						
1052	24 51.0	19.0	28.0						
1058	11 88.8	46.0	0.0	....	53 2.7	− 6 32.3	+10.1	....	40.5
1111	23 84.8	25.0	22.0		39 51.2	+ 6 38.1	+11.0	....	40.3
1133	15 80.8	....	....		44 0.9	+ 2 28.2	+11.0	....	40.1
1143	11 4.0	42.0	5.0						
1252	4 77.0	28.0	18.5						
1268	29 0.5	31.0	16.0	....	59 6.9	−12 33.2	+ 6.7	....	40.4
1320	14 88.5	40.0	7.5						
1339	10 53.0	18.0	28.0	....	48 50.5	− 2 15.4	+ 6.2	....	41.3
1397	12 41.0	....	....		52 52.5	− 6 20.1	+ 8.8	....	41.2
1398	10 62.5	20.0	27.0		53 45.2	− 7 15.6	+ 8.8	....	38.4
1414	24 64.0	43.0	4.0						

NOVEMBER 10, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
8212	3 76.0	8.0	40.0						
8223	20 47.0	42.0	6.0		41 37 59.5	+ 8 39.3	+ 1.1	....	41 46 40.0
8237	26 2.0	....	....	....	35 7.0	+11 31.8	+ 1.1	....	39.9
8330	26 44.0	16.0	42.0						
8374	15 75.5	....	....		41 8.6	+ 5 32.1	0.0	....	40.7
4	19 71.0	42.0	16.0	....	43 12.0	+ 3 29.2	0.0	....	41.2
146	9 53.7	33.0	23.0						
166	14 42.0	42.0	14.0	....	49 4.7	− 2 31.8	+10.4	....	43.3
299	8 23.7	18.0	40.0						
314	24 54.0	22.0	35.0	....	38 22.3	+ 8 26.7	− 9.9	....	39.1
480	12 44.0	28.0	29.0	....					
501	20 33.5	15.0	42.0	Cloudy...	42 46.6	+ 4 2.3	− 7.7	....	41.2

NOVEMBER 12, 1873.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
7778	2 35.0	25.0	26.0						
7798	34 47.7	42.0	10.0	....	41 63 10.3	−16 38.5	+ 8.6	....	41 46 40.4
7815	18 82.2	31.0	20.0						
7843	17 6.0	38.0	12.0	....	45 36.2	+ 0 54.8	+10.1	....	41.1
7880	16 86.2	23.0	24.5						
7894	19 80.0	29.0	18.5	....	45 8.5	+ 1 31.3	+ 2.4	....	42.2
7962	28 50.5	31.0	28.0	....	57 41.0	−11 9.3	+ 6.1	....	37.8
7972	6 97.0	40.0	21.0						
7994	8 5.0	39.0	24.0	....	47 1.9	− 0 33.5	+ 8.3	....	36.7
8024	6 71.5	32.0	30.0						
8032	22 33.5	45.0	20.0	....	54 37.7	− 8 5.5	+ 7.4	....	39.6
8212	4 87.0	33.0	30.0						
8223	21 66.0	....	....	....	37 59.8	+ 8 41.8	− 1.8	....	39.8
8237	27 24.5	27.0	36.5	....	35 7.2	+11 35.4	− 1.7	....	40.9
8256	36 46.5	....	....	....	49 48.2	− 3 23.1	+16.0	....	41.1
8284	6 18.0	....	....	....	34 7.2	+12 18.1	+16.0	....	41.3
8322	29 93.0	34.0	29.0						
8330	27 10.0	....	....						
8374	16 86.0	58.0	5.0	....	41 8.7	+ 5 18.3	+ 16.0	....	43.0

Observations and computations for latitude of Fort Fred Steele, Wyo.—Continued.

NOVEMBER 12, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
51	25 82.3	34.5	30.0						
58	12 81.0	44.0	21.0	....	41 39 45.4	+ 6 44.4	+ 7.7	....	41 46 37.5
101	3 95.0	38.0	27.0						
114	35 29.0	49.0	16.5	....	30 16.4	+16 14.0	+ 12.0	....	42.4
146	10 64.3	....	....	....	49 5.0	− 2 39.2	+14.3	....	40.1
153	26 30.3	35.0	27.0	....	40 57.4	+ 5 27.5	+14.3	....	39.2
166	15 76.5	53.0	9.0						
215	36 80.7	25.5	30.0						
239	10 80.0	42.0	14.0	....	60 7.3	−13 34.5	+6.4	....	39.2
250	0 2.0	24.5	33.0	50s. late.					
282	12 66.5	42.0	16.0	....	40 1.0	+ 6 33.0	+ 4.8	+ 0.2	39.0
299	9 97.0	20.0	27.0						
314	25 93.0	38.0	19.0	....	38 22.6	+ 8 16.0	+ 3.3	....	41.9
330	13 42.0	31.0	25.5						
343	16 90.5	32.0	25.0	....	48 25.1	−1 48.3	+ 3.4	....	40.2
409	17 17.5	35.5	20.0						
441	25 70.0	37.5	20.0	....	42 7.9	+4 25.0	+ 8.2	....	41.1
480	12 68.0	28.0	31.0						
501	20 17.0	33.5	25.0	....	42 46.9	+ 3 52.8	+ 1.5	....	41.2
558	24 7.0	33.5	26.5						
569	20 4.0	50.0	10.0	....	44 20.2	+ 2 5.3	+13.2	....	38.7
610	23 8.0	39.0	20.0	....	39 11.8	+ 7 25.2	+ 4.6	....	41.6
620	11 14.2	29.0	31.0	....	54 9.4	− 7 35.4	+ 3.7	....	37.8
686	8 75.5	39.5	20.5						
707	25 79.3	27.0	33.5	....					
885	14 64.8	36.0	23.5						
904	21 32.0	43.0	17.0	....	49 58.3	− 3 27.4	+10.5	....	41.4
1007	15 77.0	....	....	....	45 20.7	+ 0 59.4	+18.1	....	38.2
1011	23 6.5	39.0	20.0	....	41 33.9	+ 4 46.1	+18.1	....	38.1
1017	13 86.0	53.0	6.0	Releveled.					
1052	23 73.2	25.0	33.0						
1058	11 74.0	10.0	*48.0	....	53 3.4	− 6 12.7	−12.6	....	38.1

NOVEMBER 18, 1872.

8330	25 96.2	36.0	8.0						
4	19 59.5	31.0	†16.0	....	41 43 13.0	+ 3 17.9	+11.9		41 46 42.8

NOVEMBER 21, 1872.

857	21 44.8	....	....	....	41 37 10.8	+ 9 37.1	− 7.1	....	41 46 40.8
858	18 48.5	33.0	25.0	....	38 42.1	+ 8 5.0	− 7.1	....	40.0
872	2 88.0	12.0	46.0						
885	14 35.5	29.0	27.5						
904	20 60.0	18.0	40.0	Cloudy . .	49 59.9	− 3 14.1	− 5.6	....	40.2

* Observer became sick. † Clouds prevented further observations.

Observations and computations for latitude of Fort Fred Steele, Wyo.—Continued.

NOVEMBER 24, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.				° ′ ″	′ ″	″		° ′ ″
7623	17 73.5	16.0	37.0						
7631	26 62.0	32.5	20.0	....	41 42 7.2	+ 4 36.1	− 2.3	....	41 46 41.0
7699	17 11.8	26.5	24.0						
7712	19 20.5	24.0	26.0	....	47 43.3	− 1 4.9	+ 0.1	....	38.5
7754	12 28.0	....	....	....	57 6.2	−10 33.6	+ 8.8	....	41.4
7778	0 52.0	22.0	28.0	....	63 10.4	−16 39.1	+ 8.8	....	40.1
7798	32 66.7	45.0	7.0						
7962	27 89.5	28.0	18.0						
7972	6 91.0	3.0	43.5	....	57 41.4	−10 52.2	− 8.8	....	40.4
8024	5 98.0	29.5	17.0	....	54 12.1	− 7 45.1	+13.1	....	40.1
8083	3 71.0	16.0	33.5	....	60 48.2	−14 11.9	+ 4.8	....	41.1
8091	20 94.5	42.0	7.0						
8097	31 12.0	....	....						
8284	5 87.0	5.0	35.5						
8322	30 18.0	28.0	16.0	....	34 8.7	+12 35.6	− 5.1	....	39.2
8330	27 37.3	28.0	16.0						
8374	16 87.5	23.0	21.0	....	41 10.2	+ 5 26.3	+ 3.6	....	40.1
4	20 82.2	....	....	....	43 13.7	+ 3 23.6	+ 3.6	....	40.9
146	10 4.0	28.5	11.5	....	49 6.6	− 2 34.5	+ 9.5	....	41.6
153	25 75.0	....	....	....	40 59.0	+ 5 33.7	+ 9.5	....	42.2
166	15 1.2	29.0	11.5						
299	10 55.0	18.5	27.0						
314	26 23.0	48.0	− 3.0	....	38 24.3	+ 8 7.3	+10.1	....	41.7
330	13 49.0	33.0	12.5						
343	17 18.5	27.0	18.0	....	48 26.9	− 1 54.8	+ 8.1	....	40.2
409	17 40.5	30.0	16.0	....	48 32.7	− 1 1.7	+ 9.4	....	40.4
558	24 23.0	25.0	21.5						
569	20 13.0	42.5	4.0	....	44 22.1	+ 2 7.4	+11.5	....	41.0
610	23 10.0	24.0	33.0						
686	8 71.2	23.0	25.5	30 s. late ..	39 13.6	+ 7 27.2	− 3.2	+ 0.1	37.7
757	16 40.8	....	....	....	49 58.1	− 3 9.5	− 7.0	....	41.6
759	31 38.0	30.5	18.0	....	57 42.4	−10 54.9	− 7.0	....	40.5
816	10 31.0	5.0	43.0						
831	27 83.0	13.5	32.5						
857	21 14.0	42.0	3.0	....	50 4.6	− 3 27.9	+ 5.5	....	42.2
858	18 23.0	42.0	3.0						
872	2 91.0	7.0	36.5	....	38 42.6	+ 7 56.1	+ 2.6	....	41.3
915	25 51.5	16.0	25.0	•					
962	11 22.2	37.0	5.0	....	54 1.0	− 7 24.2	+ 6.3	....	43.1
1007	20 3.6	25.0	17.0	....	45 22.9	+ 1 2.3	+13.7	....	38.9
1011	27 35.0	....	....	....	41 36.1	+ 4 49.7	+13.7	....	39.5
1017	18 3.0	47.0	− 5.0						
1052	24 2.5	30.0	27.0						
1058	11 83.5	17.0	40.0	....	53 5.5	− 6 18.9	− 5.5	....	41.1
1111	24 82.0	31.0	26.0						
1143	11 72.0	30.5	26.0	....	39 53.7	+ 6 47.1	+ 2.6	....	43.4
1305	28 7.5	26.0	33.0						
1320	15 24.0	52.0	7.0	....	39 48.9	+ 6 38.9	+10.4	....	38.2
1397	16 41.0	....	....	....	52 54.4	− 6 13.6	− 1.5	....	39.3
1398	14 70.0	30.5	32.0	....	53 47.6	− 7 6.7	− 1.5	....	39.4
1414	28 43.0	29.0	33.0						
1527	30 88.0	30.0	31.0						
1536	5 24.5	15.0	46.0	Cloudy ...	60 3.6	−13 16.7	− 8.8	....	38.1

Observations and computations for latitude of Fort Fred Steele, Wyo.—Continued.

NOVEMBER 26, 1872.

Number of star.	Micrometer-readings.	Level.		Remarks.	Half sum of declination.	Corrections.			Latitude.
		N.	S.			Micrometer and reference.	Level.	Meridian.	
					° ′ ″	′ ″	″		° ′ ″
480	12 76.5	27.0	33.0						
501	20 47.2	21.0	39.0	....	41 42 50.5	+ 3 59.5	− 6.6	....	41 46 43.4
558	23 58.5	34.0	25.0						
569	19 70.3	52.0	7.0	....	44 22.4	+ 2 0.7	+14.9	....	38.0
831	28 56.2	19.0	34.0						
858	19 26.8	22.5	31.0	....	51 36.3	− 4 48.9	− 6.4	....	41.0
915	26 40.0	15.0	39.0						
962	12 24.0	37.0	18.0	....	54 1.3	− 7 20.1	− 1.3	....	39.9
1007	19 39.0	28.0	25.0						
1017	17 38.0	48.0	5.0	....	45 23.2	+ 1 2.5	+12.6	....	38.3
1052	24 50.8	24.0	30.0						
1058	12 23.0	18.0	36.0	....	53 5.8	− 6 21.6	− 6.6	....	37.6
1111	24 85.8	28.0	26.0	....	39 54.0	+ 6 32.5	+12.9	....	39.4
1133	16 82.5	....	....	....	44 3.7	+ 2 22.8	+13.2	....	39.7
1143	12 23.0	50.0	5.0						
1252	5 80.0	29.0	26.0						
1268	30 39.6	53.0	2.0	....	59 9.8	−12 44.4	+14.8	....	40.2
1305	28 31.0	30.0	26.0	....	39 49.3	+ 6 37.5	+11.0	....	37.8
1320	15 52.0	46.0	10.0						
1339	11 17.0	12.0	43.0	....	48 53.3	− 2 15.2	+ 1.3	....	39.4
1397	16 37.2	....	....	....	52 54.7	− 6 13.5	− 2.9	....	38.3
1398	14 64.0	29.5	25.0	....	53 47.9	− 7 7.3	− 2.9	....	37.7
1414	28 39.0	20.0	35.0						

NOVEMBER 27, 1872.

Number of star.	Micrometer-readings.	Level N.	Level S.	Remarks.	Half sum of declination.	Micrometer and reference.	Level.	Meridian.	Latitude.
7623	16 62.5	31.0	20.0						
7631	25 56.3	15.0	35.0	....	41 42 7.1	+ 4 37.8	− 2.4	....	41 46 42.5
7699	16 54.0	19.5	26.5						
7712	18 72.0	35.0	10.0	....	47 43.5	− 1 7.8	+ 4.9	....	40.6
7754	11 56.3	22.0	23.0						
7798	31 42.0	3.0	40.0	....	57 6.2	−10 17.1	−10.4	....	38.7
7962	26 85.5	2.0	26.0						
7972	5 65.0	16.5	30 0	....	57 41.4	−10 59.0	− 3.7	....	38.7
8024	4 67.5	19.0	29.0	....	54 12.3	− 7 41.9	+ 9.9	....	40.3
8083	2 49.5	2.0	46.0	....	60 48.5	−14 10 1	+ 0.6	....	39.0
8091	19 53.5	47.0	1.0						
8097	29 84.7								
8212	3 90.3	20.0	24.5						
8223	20 73.8	19.0	27.0	....	38 1.1	+ 8 43.2	− 3.4	....	40.9
8237	26 28.0	....	....	....	35 8.5	+11 35.5	− 3.4	....	40.6
8284	5 41.0	21.0	27.0						
8322	29 78.7	15.0	32.0	....	34 8.9	+12 37.6	− 6.3	....	40.2
8330	26 98.0	15.0	32.0						
8374	16 40.0	35.0	12.0	....	41 9.9	+ 5 28.8	+ 1.7	....	40.4
4	20 36.8	....	....	....	43 13.4	+ 3 25.5	+ 1.7	....	40.6
51	24 75.5	24.5	25.0						
58	11 63.0	33.0	15.5	....	39 47.2	+ 6 47.9	+ 4.6	....	39.7
146	10 64.0	26.0	21.0	....	49 6.9	− 2 39.4	+11.2	....	38.7
153	26 31.0	....	....	....	40 59.9	+ 5 27.6	+ 4.2	....	38.7
166	15 77.0	41.5	5.5						
215	37 43.3	22.0	24.5						
239	11 49.0	18.0	28.0	....	60 9.3	−13 26.3	− 3.4	....	39.6

Observations and computations for latitude of Fort Fred Steele, Wyo.—Continued.

NOVEMBER 27, 1872.

Number of star.	Micrometer readings.	Level. N.	Level. S.	Remarks.	Half-sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
250	0 84.5	33.5	13.5						
282	13 56.8	18.0	28.0	....	41 40 2.9	+ 6 35.4	+ 2.7	....	41 46 41.0
299	10 71.0	24.0	23.0						
314	26 80.0	17.0	30.0	....	38 24.7	+ 8 20.1	− 3.3	....	41.5
330	12 12.0	31.0	16.0						
343	15 80.3	30.0	18.0	....	48 27.3	− 1 54.5	+ 7.4	....	40.2
409	16 5.0	34.0	12.5						
441	24 64.0	21.0	25.5	....	42 10.1	+ 4 27.0	+ 4.6	....	41.7
558	23 79.6	30.0	12.5						
569	19 26.3	10.0	33.0	....	44 22.7	+ 2 20.9	− 1.5	....	42.1
757	15 0.5	....	....	....	49 58.4	− 3 10.7	− 6.6	....	41.1
759	29 96.0	24.0	23.0	....	57 42.6	−10 55.5	− 6.6	....	40.5
816	8 87.0	11.0	36.0						
857	21 59.0	....	....	....	37 11.7	+ 9 27.9	+ 1.5	....	41.1
858	18 63.0	24.0	23.5	....	38 43.1	+ 7 55.9	+ 1.5	....	40.5
872	3 31.7	27.0	22.0						
885	14 0.2	21.0	27.0						
904	20 66.5	44.0	4.0	....	50 0.8	− 3 27.1	+ 9.3	....	43.0
915	25 2.7	19.0	28.0						
962	10 84.6	28.5	18.0	....	54 1 5	− 7 20.7	+ 0.4	....	41.2
1007	19 94.0	22.0	26.0	Must be 18t	45 23.3	+ 1 5.3	+10.4	....	39.0
1011	26 29.5	....	....	....	41 36.6	+ 4 53.9	+10.4	....	40.9
1017	16 84.0	45.0	3.0						
1052	24 96.0	22.0	25.0						
1058	12 55.0	24.0	23.0	....	53 5.9	− 6 25.7	− 0.5	....	39.7
1111	24 85.5	25.5	22.5	....	39 54.1	+ 6 33.8	+12.1	....	40.0
1133	16 81.3	....	....	....	44 3.9	+ 2 23.9	+12.1	....	39.9
1143	12 18.3	45.0	4.0						
1252	5 55.0	25.0	25.0						
1268	29 75.5	29.0	19.0	....	59 9.9	−12 32.3	+ 2.7	....	40.3
1305	27 61.5	28.0	20.0	....	39.49.5	+ 6 49.5	+ 1.8	....	40.8
1320	14 44.0	23.5	25.0						
1339	10 13.5	28.0	20.0	....	48 53.5	− 2 13.8	+ 1.8	....	41.5
1397	14 92.2	....	....	....	52 54.8	− 6 24.2	+ 9.9	....	40.5
1398	13 18.5	32.0	18.0	....	53 48.1	− 7 18.1	+ 9.9	....	39.9
1414	27 28.2	36.0	14.0						

Resulting astronomical co-ordinates.

The daily results, combining the observations of November 10, 18, 21, and 26, to one result, will be:

	No. of obs.	° ′ ″
November 4	31	41 46 40.30
6	27	40.18
8	30	40.41
12	28	39.99
10, 18, 21, and 26	24	40.00
24	30	40.37
27	36	40.42

Giving every mean the same weight, the final result for the latitude of Fort Fred Steele will be:

Latitude .... 41° 46′ 40″.24 ± 0″.05

Longitude .... 7*h*. 7*m*. 47*s*.25 or 106 56 48 .80 west of Greenwich.
1 59 35 .13 or 29 53 47 .00 west of Washington.

LARAMIE.

Longitude—105° 35′ 33″.60 W.
Latitude—41° 18′ 51″.8 ± 0″.08 N.

At Laramie, a point in an open lot northeast from and near the railroad depot was selected as the station. It was not a desirable locality, but was about the only alternative by reason of the position of the telegraph wires. There was no possible objection to the position so far as the surface of the land was concerned, for the entire vicinity is but a gently undulating plain; but the observatory being in the middle of the city, the view both north and south was intercepted at short distances by houses, making it impossible to lay out any extended meridian line. Laramie stands centrally on the great plateau bearing the well-known name "Laramie Plains," and to my notion is the most inviting town on the whole transcontinental route. These plains, though some 7,000 feet above the level of the sea, are well clothed in grass, (but destitute of other forms of vegetation,) and watered by the Laramie River, which flows with a gentle current northerly through the valley. Mountains are visible to the right and left, and though from 8,000 to 10,000 feet high, appear only as slight ridges and low peaks from this elevated plateau.

Meteorological.—Two weeks of December were spent here, and the meteorological conditions experienced found to be very similar to those of the previous month at Fort Steele. The same violent dust and snow-storms prevailed, and though not quite so cold as it had been, it was not possible to run the observatory without a stove. Here, as at Fort Steele, there were times when it required the best exertion of the observers to keep the observatory and all its appliances from being blown away.

Observatory.—The observatory consisted of a hospital-tent—the same that was used at Cheyenne. The assistants were also the same. The operator was Mr. Williams, of the Western Union line.

Instruments.—Precisely the same as were used at Cheyenne and Fort Steele.

Connections.—Connection was made with Salt Lake by a loop into the main wire of the Western Union line. Some observations for latitude were made on each of the nights of December 6, 7, 8, 11, 13, 15, and 17. On the nights of the 9th, 12th, and 16th, observations for time were made and exchanged with Salt Lake for difference of longitude. Of all the stations occupied by Assistant J. H. Clark this has proven the least satisfactory, by reason of smoke and dust, and the near vicinity of moving trains.

Instrumental values.—See report on the Cheyenne station.

Table containing the corrections of chronometers and their rates.

LARAMIE.

Correction of Salt Lake chronometer.

1872.	Local sidereal time.	Correction of chronometer.	Adopted rate.
	h.	*h. m. s.*	*h.*
December 9	2.2	−0 1 34.73	0.115
December 12	1.0	26.41	0.115
December 16	1.0	−0 1 15.28	0.116

Correction of Laramie chronometer.

1872.	Local sidereal time.	Correction.	Adopted rate.
	s.	*h. m. s.*	*s.*
December 9	1.75	−1 53 11.56	−0.107
December 12	3.00	3.78	−0.107
December 16	3.00	−1 52 54.72	−0.094

Grouping of time signals and corrections and resulting longitudes.

Signals sent from—	Recorded at—	Mean of signals, sent and received.	Time corrections.	Corrected time.	Difference of longitude.	Double wave-time.	Means.
		h. m. s.	*h. m. s.*	*h. m. s.*	*h. m. s.*		
Salt Lake	Salt Lake	2 32 19.90	−0 1 34.70	2 30 45.20			
	Laramie	4 49 9.25	−1 53 11.41	2 55 57.84	0 25 12.64		
Laramie	Salt Lake	2 39 13.57	−0 1 34.69	2 37 38.88			
	Laramie	4 56 2.93	−1 53 11.40	3 2 51.53	12.65	....	12.64
Salt Lake	Salt Lake	2 39 5.32	−0 1 26.23	2 37 39.09			
	Laramie	4 55 55.49	−1 53 3.78	3 2 51.71	12.62		
Laramie	Salt Lake	2 45 16.19	−0 1 26.21	2 43 49.98			
	Laramie	5 2 6.36	−1 53 3.76	3 9 2.60	12.62	....	12.62
Salt Lake	Salt Lake	3 6 39.93	−0 1 15.04	3 5 24.89			
	Laramie	5 23 32.19	−1 52 54.67	3 30 37.52	12.63		
Laramie	Salt Lake	3 13 3.74	−0 1 15.03	3 11 48.71			
	Laramie	5 29 55.95	−1 52 54.66	3 37 1.29	12.58	....	12.61

Final difference of longitude: Laramie, east of Salt Lake, $0^h\ 25^m\ 12^s.623 \pm 0^s.008$.

Observations and computations for latitude of Laramie, Wyo.

DECEMBER 6, 1872.

Number of star.	Micrometer-readings.	Level.		Remarks.	Half sum of declination.	Corrections.			Latitude.
		N.	S.			Micrometer and reference.	Level.	Meridian.	
	t. d.	*d.*	*d.*		° ′ ″	′ ″	″		° ′ ″
8174	9 15.8	28.5	28.5						
8188	27 25.5	12.0	44.0	....	41 9 40.3	+ 9 22.4	− 8.8	....	41 18 53.9
8248	21 87.0	31.0	26.0						
8273	15 81.0	17.0	39.0	....	23 3.4	− 3 8.3	− 4.6	....	50.5
8279	22 54.0	34.0	23.0						
8296	13 97.5	....	....	....	14 19.1	+ 4 26.2	+ 6.7	....	52.0
8301	18 52.5	34.5	21.0	....	16 29.0	+ 2 16.4	+ 6.7	....	52.1
68	19 12.0	31.0	23.0						
98	8 46.7	31.0	24.0	....	13 18.6	+ 5 31.1	+ 4.1	....	53.8
116	9 25.0	....	....	....	13 43.1	+ 5 6.7	+ 4.1	....	53.9
146	34 28.5	25.0	31.0						
164	3 83.0	53.0	3.0	....	2 50.3	+15 46.5	+12.1	....	48.9
201	19 72.0	32.0	23.0						
224	16 0.5	49.5	5.0	....	16 41.8	+ 1 55.4	+14.7	....	51.9
250	18 32.7	29.0	25.0						
255	19 21.5	12.5	42.0	....	18 34.4	+ 0 27.6	− 7.0	....	55.0
339	20 92.0	32.0	23.0						
401	16 76.0	42.0	11.0	....	16 31.9	+ 2 9.3	+11.0	....	52.2
430	10 3.5	32.0	20.0						
450	26 8.2	15.0	37.0	....	10 35.0	+ 8 18.7	− 2.8	....	50.9
533	15 76.2	21.5	29.5						
564	23 66.2	*27.0	27.5	....	14 50.2	+ 4 5.4	− 3.7	....	51.9

* Must be $22^d.0$.

Observations and computations for latitude of Laramie, Wyo.—Continued.

DECEMBER 6, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
666	20 93.2	27.5	24.5						
695	20 31.3	— 2.0	48.0	....	41 19 27.6	— 0 19.3	—12.9	....	41 18 55.4
943	20 27.0	24.0	30.0						
980	20 7.0	52.0	2.0	....	18 30.4	+ 0 6.2	+12.1	....	48.7
1017	10 79.0	30.0	25.0	30s late ...					
1024	25 67.0	29.0	26.0	....	11 7.9	+ 7 42.5	+ 2.2	+0.1	52.7
1058	26 26.5	38.5	16.0	....	8 37.0	+10 7.3	+10.7	....	55.0
1107	6 72.5	36.5	20.0						
1117	22 86.8	26.0	31.0	....	10 26.7	+ 8 21.7	+ 3.2	....	51.6
1204	14 24.7	42.0	17.5						
1221	26 98.5	25.0	32.0	....	25 24.5	— 6 35.9	+ 4.8	....	53.4

DECEMBER 7, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
863	33 85.0	25.0	22.0						
872	3 30.5	8.5	39.5	40s late ...	41 3 10.2	+15 49.3	— 7.7	+0.1	41 18 51.9
948	18 77.2	28.0	19.5						
980	18 28.5	30.0	20.0	....	18 30.6	+ 0 15.1	+ 5.1	....	50.8
1017	11 72.0	29.0	20.0						
1024	26 90.0	....	....	....	11 8.1	+ 7 51.8	— 8.4	....	51.5
1035	18 54.2	4.5	44.0	....	15 27.7	+ 3 32.0	— 8.4	....	51.3
1058	86 91.0	18.5	31.0	....	8 37.1	+10 9.8	+ 7.5	....	54.4
1107	7 29.0	44.5	5.0						
1133	30 73.0	24.0	23.0						
1140	6 38.0	32.5	13.0	....	6 9.6	+12 36.8	+ 5.6	....	52.0
1204	12 82.0	27.5	20.0						
1221	25 81.5	39.0	7.5	....	25 24.4	— 6 43.9	+10.8	....	51.3
1238	11 60.0	26.0	20.0						
1261	24 52.7	10.0	37.0	....	12 12.8	+ 6 41.8	— 5.7	....	48.9
1286	13 75.2	26.0	23.0						
1316	23 49.0	21.5	26.9	....	23 54.7	— 5 2.7	— 0.4	....	51.6
1382	27 44.5	28.0	19.0						
1408	9 85.3	14.0	30.0	....	9 46.9	+ 9 6.7	— 2.0	....	51.6
1651	18 49.7	20.0	25.0						
1676	17 76.5	19.0	26.0	....	19 16.4	— 0 22.7	— 3.3	....	50.4
1721	21 98.0	25.0	20.0						
1726	18 34.0	....	....	....	17 2.5	+ 1 53.1	— 3.3	....	52.3
1734	15 45.5	15.0	32.0	....	15 32.0	+ 3 22.8	— 3.3	....	51.5

DECEMBER 8, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
7824	12 6.5	18.5	22.0						
7843	7 82.3	23.0	16.0	....	41 16 6.8	+ 2 42.9	+ 1.0	....	41 18 50.7
7931	20 71.0	21.5	18.0						
7948	17 88.8	3.0	37.0	....	20 25.4	— 1 27.7	— 8.4	....	49.3
7994	27 39.5	18.0	23.0						
8023	30 70.5	19.0	22.5	....	17 12.9	+ 1 42.9	— 2.3	....	53.5
8079	19 98.0	42.0	10.0						
8083	20 1.0	0.0	52.0	....	18 58.2	+ 0 0.9	— 5.5	....	53.6

Observations and computations for latitnde of Laramie, Wyo.—Continued.

DECEMBER 8, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
8174	9 97.0	33.0	24.C						
8188	27 74.5	21.0	35.5	....	41 9 40.4	+ 9 12.5	− 1.5	....	41 18 51.4
8248	21 93.8	28.5	29.0						
8273	15 96.8	21.0	38.0	....	22 3.4	− 3 5.6	− 4.8	....	53.0
68	23 2.0	30.0	29.0						
98	12 24.8	29.0	32.0	....	13 18.7	+ 5 34.8	− 0.6	....	52.9
116	13 3.5	....	....	....	13 43.1	+ 5 10.3	− 0.6	....	52.8
146	34 49.0	23.0	37.5						
164	3 58.0	42.5	19.0	....	2 50 4	+16 0.7	+ 2.5	....	53.6
201	20 27.0	24.0	22.0						
224	16 25.0	28.0	18.0	....	16 41.9	+ 2 4.9	+ 3.3	....	50.1
290	22 81.0	31.0	14.0						
299	15 85.5	10.0	34.0	....	15 15.0	+ 3 36.2	− 2.0	....	49.2
339	20 82.0	27.0	18.5						
401	16 42.6	19.5	26.0	....	16 32.1	+ 2 16.6	+ 0.6	....	49.3
430	10 49.0	25.0	21.0						
450	26 95.5	0.0	47.0	....	10 35.0	+ 8 31.6	−11.9	....	54.7
474	16 78.7	25.0	22.0	....	20 24.8	− 1 34.3	− 0.5	....	50.0
487	21 90.0	....	....	....	17 44.9	+ 1 4.7	− 0.5	....	49.1
516	19 82.0	21.0	26.0						
533	15 10.5	23.0	24.0						
535	12 52.0	14.5	33.0	....	20 17.4	− 1 20.3	− 5.4	....	51.7
564	23 5.0	16.0	32.0	....	14 50.4	+ 4 6.3	− 5.4	....	51.3
863	33 57.2	25.0	25.0						
872	3 39.0	33.0	18.0	....	3 10.4	+15 38.0	+ 4.1	....	52.5
948	19 83.0	26.0	24.5						
980	19 17.0	28.0	22.0	....	18 30.7	+ 0 20.5	+ 2.1	....	53.3
1107	6 92.0	30.5	20.0						
1117	22 99.9	35.5	16.0	....	10 26.9	+ 8 19.7	+ 8.1	....	54.7
1133	31 21.5	31.0	18.5						
1140	6 99.4	31.0	17.5	....	6 9.8	+12 32.8	+ 7.2	....	49.8
1204	13 34.5	29.0	20.0						
1121	25 93.0	22.0	26.5	....	25 24.5	− 6 31.1	+ 1.2	....	54.6
1238	12 5.0	21.0	27.0						
1261	25 3.0	15.0	35.5	....	12 18.0	+ 6 43.4	− 7.3	....	54.1
1382	27 80.5	33.0	19.5						
1408	10 70.0	37.0	14.0	....	9 49.5	+ 8 51.6	−10.0	....	51.1

DECEMBER 11, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
8317	15 25.5	22.0	24.0						
8337	32 1.0	10.5	35.0	....	27 39.8	− 8 40.8	− 7.3	....	51.7
68	23 19.0	20.0	26.0						
98	12 4.0	4.0	42.0	....	13 18.9	+5 46.5	−12.1	....	53.3
116	12 85.2	....	....	....	13 43.3	+5 21.3	−12.1	....	52.5
122	11 96.2	....	....	....	13 15.8	+5 49.0	−12.1	....	52.7
201	20 68.5	24.0	24.5						
224	16 35.2	15.0	32.0	....	16 42.1	+ 2 14.7	− 4.8	....	52.0
250	19 24.2	26.0	20.0						
255	20 4.8	9.0	37.0	....	18 34.6	+ 0 25.6	− 6.0	....	53.6

Observations and computations for latitude of Laramie, Wyo.—Continued.

DECEMBER 11, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half-sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
430	10 63.8	28.0	19.0						
450	26 86.0	4.0	43.0	....	41 10 35.3	+ 8 24.2	− 8.2	....	41 18 51.3
474	16 22.0	15.0	30.0	....	20 25.0	− 1 41.3	+ 5.7	....	49.4
487	21 37.0	....	....	....	17 45.2	+ 0 58.7	+ 5.7	....	49.6
516	19 48.0	42.0	6.0						
533	15 90.5	25.0	23.0						
564	24 4.0	5.0	44.5	....	14 50.7	+ 4 12.8	−10.3	....	53.2
698	27 9.0	28.0	22.0						
715	15 63.8	12.0	38.0	....	24 54.3	− 5 55.9	− 5.5	....	52.9
735	7 78.0	....	....	....	28 26.5	− 9 29.0	− 5.5	....	52.0
786	23 32.3	30.0	21.0						
827	12 31.0	0.0	51.0	....	24 44.7	− 5 42.3	−11.6	....	50.8
863	33 96.0	28.0	23.5						
872	3 56.0	18.0	34.0	....	3 10.7	+15 44.8	− 3.2	....	52.3
948	19 14.0	29.0	22.0						
980	18 79.0	42.0	7.0	....	18 31.2	+ 0 10.9	+11.6	....	53.7
1017	12 2.0	20.0	26.0						
1024	26 72.6	....	....	....	11 8.6	+ 7 37.1	+ 5.2	....	50.9
1035	18 36.2	35.0	10.0	....	15 28.3	+ 3 17.1	+ 5.2	....	50.6
1058	25 96.5	22.0	24.0						
1007	6 56.8	45.0	2.0	....	8 37.6	+10 2.9	+11.2	....	51.7
1133	39 29.3	25.5	21.0						
1140	6 66.0	13.0	34.0	....	6 10.1	+12 45.6	−4.5	....	51.2
1204	12 88.0	30.0	17.0						
1221	25 75.2	26.0	20.0	....	25 24.9	− 6 40.1	+ 5.2	....	50.0
1238	11 65.0	18.0	26.0						
1261	24 46.0	20.0	25.0	....	12 18.4	+ 6 38.1	+ 3.5	....	53.0

DECEMBER 13, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half-sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
68	21 63.6	23 0	15.0						
98	10 86.5	....	....	....	41 13 19.0	+ 5 34.8	− 1.1	....	41 18 52.7
116	11 66.7	13.0	25.0	....	13 43.3	+ 5 9.8	− 1.1	....	52.0
122	10 78.3	....	....	....	13 15.9	+ 5 37.3	− 1.1	....	52.1
201	19 44.8	31.0	26.0						
224	15 6.8	13.0	44.0	....	16 42.1	+ 2 16.1	− 7.2	....	51.0
250	16 93.0	29.0	29.0						
255	18 56.0	28.0	30.0	Must be 17t	18 34.7	+ 0 19.6	− 0.6	....	53.7
290	21 87.5	29.0	29.0						
299	15 17.8	42.0	17.0	....	15 15.5	+ 3 28.1	+ 6.8	....	50 4
533	16 10.2	29.0	28.0						
564	24 10.5	17.0	40.0	....	14 50.8	+ 4 8.7	− 6.1	....	53.4
620	32 54.5	27.0	27.0						
632	4 59.8	54.0	0.0	....	4 6.1	+14 28.6	+14.8	....	49.5
657	18 98.3	....	....	....	19 30.5	− 0 33.3	− 5.7	....	51.5
666	18 92.5	24.0	19.0	....	19 28.2	− 0 31.4	− 5.7	....	51.1
695	17 91.3	18.0	34.0						
752	19 32.5	24.5	25.0						
785	18 51.8	42.0	9.0	....	19 10.2	− 0 25.1	+ 8.9	....	54.0
948	18 61.0	31.0	23.0						
980	18 34.0	44.5	8.0	....	18 31.4	+ 0 8.4	+12.2	....	52.0

Observations and computations for latitude of Laramie, Wyo.—Continued.

DECEMBER 13, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half-sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
1017	12 0.0	34.0	17.0						
1024	27 17.0				41 11 8.9	+ 7 51.5	− 8.2		41 18 52.2
1035	18 76.0	2.0	49.0		15 28.5	+ 3 30.1	− 8.2		50.4
1062	20 48.0	42.0	9.0						
1095	11 78.0	15.5	36.0	20^s late	14 15.9	+ 4 30.4	+ 3.4	+ 0.1	49.8
1204	12 68.0	31.0	22.5						
1221	25 47.0	31.0	24.0		25 25.2	− 6 37.5	+ 4.3		52.0
1238	11 38.0	25.0	31.0						
1261	23 81.8	45.0	11.5		12 18.7	+ 6 26.6	+ 7.6		52.9

DECEMBER 15, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half-sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitude.
8079	19 21.5	17.0	28.5						
8083	18 88.0	33.0	13.0		41 18 58.0	− 0 10.4	+ 2.3		41 18 49.9
8174	9 31.5	23.0	21.0						
8188	27 13.8	18.0	26.5		9 40.1	+ 9 13.9	− 1.8		52.2
8248	21 16.2	20.0	24.0						
8273	14 85.0	30.5	14.0		22 3.4	− 3 16.2	+ 3.4		50.6
8279	23 13.0	29.0	16.0						
8296	14 42.0				14 19.1	+ 4 30.7	+ 2.6		52.4
8301	18 61.0	21.5	25.0		16 29.0	+ 2 20.5	+ 2.6		52.1
8310	9 68.0				30 17.2	−11 30.4	+ 4.6		51.4
8317	14 70.0	19.0	27.0		27 39.8	− 8 54.4	+ 4.6		50.0
8337	31 89.5	36.0	11.0						
8345	37 56.0	33.5	12.5						
28	1 0.3	11.5	38.0		40 59 58.6	+18 56.2	− 1.5		53.3
68	23 12.5	26.5	22.5						
98	12 37.0				41 13 19.1	+ 5 34.3	− 2.3		51.1
116	13 18.8	19.0	31.5		13 43.3	+ 5 8.8	− 2.3		49.8
122	12 28.5				13 15.9	+ 5 36.9	− 2.3		50.5
201	20 4.5	28.0	22.5						
224	16 7.5	33.5	13.0		16 42.2	+ 2 3.4	+ 7.2		52.8
250	17 61.0	21.5	25.0						
255	18 32.0	20.0	27.0		18 34.8	+ 0 22.1	− 2.9		54.0
290	21 74.0	37.0	9.0						
299	15 10.2	29.0	15.0		15 15.5	+ 3 26.3	+11.6		53.4
339	21 62.5	27.0	16.5						
401	17 45.3	35.5	7.5		16 32.5	+ 2 9.7	+10.6		52.8
430	9 73.0	23.0	20.0						
450	25 81.0	12.5	30.5		10 35.7	+ 8 19.8	− 4.4		51.1
474	15 93.5				20 25.4	− 1 36.7	+ 2.2		50.9
487	21 13.5	28.5	14.0		17 45.5	+ 1 5.0	+ 2.0		52.5
516	19 4.5	17.5	25.0						
533	15 35.0	19.0	23.0						
535	12 87.0			50^s late	20 18.0	− 1 17.1	− 9.5	+ 0.1	51.5
564	23 33.5	6.0	36.5		14 51.0	− 4 8.2	− 9.5		49.7
576	24 36.0				29 26.4	−10 31.1	− 5.1		50.2
580	33 5.2	20.0	23.0		33 10.9	−14 13.7	− 5.1		52.1
579	31 52.0				33 58.0	−15 1.3	− 5.1		51.6
587	4 5.3	14.0	29.5						
620	32 37.8	22.0	23.0						
632	4 20.0	37.0	8.5		4 6.2	+14 35.8	+ 7.6		49.6

Observations and computations for latitude of Laramie, Wyo.—Continued.

DECEMBER 15, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitue.
					° ′ ″	′ ″	″		° ′ ″
657	19 17.8	....	....	....	41 19 30.7	— 0 35.2	— 4.3	....	41 18 51.2
666	19 14.0	33.5	13.0	....	19 28.4	— 0 34.0	— 4.3	....	50.1
695	18 4.5	5.0	41.0						
752	19 20.0	25.5	24.5						
785	18 57.3	25.0	25.5	....	19 10.7	— 0 19.5	+ 0.1	....	51.3
863	32 96.0	32.0	19.0						
872	2 69.0	18.5	32.0	....	3 11.0	+15 40.8	— 0.1	....	51.7
948	19 42.0	25.5	25.0						
980	18 84.0	28.0	21.0	....	18 31.7	+ 0 18.0	+ 2.1	....	51.8
1052	26 45.0	25.0	21.5	....	21 21.0	— 2 22.1	— 5.5	....	53.4
1062	21 87.8	11.5	35.0						
1095	12 98.2	33.0	14.0	....	14 16.2	+ 4 36.5	— 1.2	....	51.5
1107	6 70.0	22.0	24.5						
1117	23 3.0	15.5	31.5	....	10 27.8	+ 8 27.5	— 5.1	....	50.2
1133	31 66.5	23.0	24.0						
1140	7 43.2	37.0	10.0	....	6 10.7	+12 33.2	+ 7.1	....	51.0
1204	12 46.0	26.0	24.0						
1221	25 46.0	39.0	10.0	....	25 25.4	— 6 44.0	+ 8.8	....	50.2
1238	12 31.0	25.5	23.0						
1261	25 11.0	16.5	32.0	....	12 18.9	+ 6 37.8	— 3.5	....	53.2
1286	13 39.0	23.5	25.0						
1316	23 54.6	42.0	8.0	....	23 55.7	— 5 15.6	+ 8.9	....	49.0
1382	27 20.3	30.0	18.5						
1408	10 10.3	35.0	13.0	....	9 50.5	+ 8 51.5	+ 9.2	....	51.2
1546	12 80.4	36.0	7.5						
1572	31 0.0	24.0	24.5	....	28 11.3	— 9 25.5	+ 7.7	....	53.5
1671	19 7.0	22.0	25.0						
1676	18 38.0	16.5	30.0	....	19 17.4	— 0 21.4	— 4.5	....	51.5
1721	21 75.5	28.0	19.0						
1726	18 19.0	15.5	32.0	45^s late ...	17 3.4	+ 1 50.8	— 2.1	+ 0.1	52.2

DECEMBER 17, 1872.

Number of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half sum of declination.	Corrections. Micrometer and reference.	Corrections. Level.	Corrections. Meridian.	Latitue.
250	18 51.8	20.0	24.5						
255	19 29.5	15.0	29.5	....	41 18 34.9	+ 0 24.1	— 5.0	....	40 18 53.5
290	22 38.0	24.5	20.0						
299	15 42.0	21.5	22.0	30^s late ...	15 15.6	+ 3 36.3	+ 1.1	+ 0.1	53.1
339	19 97.0	28.5	14.5						
401	15 93.8	37.5	7.0	....	16 32.6	+ 2 5.3	+12.2	....	50.1
430	9 39.0	22.5	21.0						
450	25 30.0	23.0	20.0	....	10 35.8	+ 8 14.5	+ 1.2	....	51.5
474	15 82.5	....	....	....	20 25.6	— 1 49.6	+13.2	....	49.2
487	21 2.3	24.0	20.0	....	17 45.6	+ 0 52.0	+13.2	....	50.8
516	19 35.0	44.0	0.0						
533	14 11.0	18.0	24.0						
564	21 78.0	28.5	13.0	....	14 51.7	+ 3 58.4	+ 2.6	....	52.7
579	32 31.5	8.0	32.0						
587	4 82.0	20.0	20.0	....	33 11.1	—14 14.5	— 6.6	....	50.0
620	32 9.2	17.0	24.0						
632	3 96.7	44.0	3.0	Must be $-3^d.0$.	4 6.4	+14 34.1	+11.0	....	51.5

Observations and computations for latitude of Laramie, Wyo.—Continued.

DECEMBER 17, 1872.

Number of star.	Micrometer-readings.	Level.		Remarks.	Half-sum of declination.	Corrections.			Latitude.
		N.	S.			Micrometer and refr.	Level.	Meridian.	
	t. d.	d.	d.		° ′ ″	′ ″	″		° ′ ″
657	19 25.2	18.0	20.0	....	41 19 31.0	− 0 34.6	− 4.4	....	41 18 52.0
666	19 16.0	....	....	....	19 28.7	− 0 31.7	− 4.4	....	52.6
695	18 14.0	12.0	26.0	....					
752	18 41.0	16.5	25.0	....					
785	17 75.2	30.0	14.5	....	19 11.1	− 0 20.5	+ 1.9	....	52.5
863	33 56.8	26.0	17.5	....					
872	3 14.2	10.0	32.5	35s late ...	3 11.3	+15 45.6	− 3.8	+ 0.1	53.2
948	19 82.3	23.5	17.5	....					
980	19 38.0	33.0	6.0	....	18 32.0	+ 0 13.8	+ 9.0	....	54.8
1017	11 49.0	18.0	21.0	....					
1024	26 52.0	....	....	....	11 9.3	+ 7 47.1	− 4.9	....	51.5
1035	18 17.0	12.0	27.0	....	15 29.0	+ 3 27.6	− 4.9	....	51.7
1052	25 40.0	18.5	21.0	....	21 21.4	− 2 31.4	+ 2.1	....	52.1
1062	20 53.0	25.0	15.0	....					
1095	11 76.0	19.0	20.0	....	14 16.6	+ 4 32.6	+ 2.1	....	51.3
1133	30 92.4	20.0	18.5	....					
1140	6 66.7	31.0	8.0	....	6 11.0	+12 33.9	+ 6.7	....	51.6
1204	12 27.5	26.0	14.5	....					
1221	25 43.0	37.0	3.0	....	25 25.7	− 6 48.8	+12.5	....	49.4
1238	11 6.8	16.0	22.0	....					
1261	23 90.5	13.0	25.0	....	12 19.2	+ 6 39.0	− 4.9	....	53.3
1286	13 36.7	23.0	15.0	....					
1316	23 65.8	42.0	− 4.0	....	23 55.9	− 5 19.8	+14.8	....	50.9

Resulting astronomical co-ordinates.

The following table contains the daily means for latitude:

1872.	No. of obs.	Mean latitude obtained.
		° ′ ″
December 6	18	41 18 52.43
7	13	51.50
8	24	51.93
11	21	51.83
13	17	51.81
15	40	51.46
17	22	51.79

The mean of the daily results gives 51″.82; the mean of all observations made, 51″.78.

Adopted latitude .... 41° 18′ 51″.80 ± 0″.08
Longitude .... 7^h 2^m 22^s.24 or 105° 35′ 33″.60 west of Greenwich.
1 54^m 10^s.12 or 28° 32′ 31″.80 west of Washington

The following points are proposed for occupation as main astronomical stations during the field-season of 1874:

1. Las Vegas, N. Mex.
2. Cimarron, N. Mex.
3. Sidney Barracks, Neb.
4. Julesburgh, Neb.
5. Crossing of the Union Pacific Railroad by the one-hundredth meridian, or at the North Platte station, Nebraska.

The above will be sufficient during the coming year to answer all the wants experienced in checking belts of triangles to be extended over the area to be surveyed, and will continue the work upon the astronomical base.

The usual field-astronomical observations will be kept up, in accordance with the elaborated scheme of survey determined upon for the prosecution of further geographical work by the officers in executive charge of the several parties.

GEODETIC AND ASTRONOMICAL.

The character of the observations made in this most important branch of the survey has been improved and perfected so far as consistent with the policy of covering large geographical areas during a single field-season. The problem of conducting a geographical survey over mountainous areas by methods at once thorough and rapid presents many grave difficulties, prominent among which is the uncertainty as to the extent of the physical obstacles to be encountered. The present organization will, however, during the coming season prosecute its labors in accordance with a certain plan conditioned upon the character of the several portions of the area to be entered, and founded upon a comprehensive system of triangulation developed from bases whose extremities and azimuths are well determined, the former by astronomical methods. These series of triangles network the entire area, and in addition thereto the horizontal and vertical values of the drainage-lines of the several main and sub basins are determined.

The progress of the geodetic survey of the character proposed is somewhat slower than by the methods employed prior to the season of 1873; but when confined to areas of the public domain that are attracting attention on account of their mineral or other resources developing, and about to be developed, where the Indian tribes are quiet, the decrease in cost because of the smaller number of persons required in each party for reasons of safety makes apparent the fact that a well-established policy as to the character of the surveys over such areas may be reached. I have reason to believe that such a course is about to be adopted, and in consequence hereafter some of the parties of the survey, at least, may annually be sent to areas not occupied by hostile Indians; while other parties may be directed to more inaccessible portions of mountain-territory, where reconnoissance-work alone is required, and where escorts will be needed.

In the season of 1873, the astronomical co-ordinates of points, and the determination of meridional lines through them, were determined at Hughes', Colorado Springs, and Trindad, Col., and Fort Union, N. Mex., all on the eastern base of the Rocky Mountain range, and a series of triangles developed from bases at these points into portions of Colorado, New Mexico, Eastern Utah, and Eastern Arizona. The labors of the season of 1874 will take up the triangulation at the points where it was left in the preceding season, for the purpose of completing it over the area extending from the latitude of Denver southward to the thirty-second parallel. The several belts will be joined to a number of points, all of which are along nearly the same meridian east of the Rocky Mountain ridge. The bases are measured by compensated steel tapes, referred to a standard, and a sufficient number of repetitions made to guarantee a small probable error. The azimuths are also carefully determined.

At the extremities of the developed bases, angular measurements are taken to the most prominent points of the adjacent triangulation-belt, which points are natural objects—usually high mountain-peaks.

The extension of the triangulation is made from point to point in accordance with the plan made at the beginning of the season, and the azimuth of at least one side of every triangle determined.

Within the main or principal triangles there is measured a series of minor triangles, covering the entire mountain-area, checked latitudinally at specified points. The checks used for the remaining detailed operations of the survey are by latitudes along the meanders, and by the connection of station-points with three or more main or prominent points within the horizon of each. The belts of triangles are further controlled by interior check-bases at distances not exceeding one hundred and fifty miles from the primary astronomical point. By these methods, forty-four main-triangulation-points were occupied in New Mexico and Arizona and thirty-six in Colorado during the season of 1873.

When the connection is made between the two sets, their publication will indicate the character of the results, which have so far proven very satisfactory, since the geographical position of most of the points used could not be sufficiently ascertained in advance to always insure certainty as to resulting well-conditioned triangles.

A part of the topographic work of 1873, especially that in Colorado, demands a representation upon a scale of one inch to four miles, because of the intricate character of the several drainage-lines within the Rocky Mountain system. This will in no wise interfere with the regular and systematic plan proposed for the atlas of the region west of the one hundredth meridian. Since the final publication of the same, may be made upon a scale of one inch to eight miles.

The remarkably fruitful results from the topographical work of the past season are a matter of much congratulation to me, since the several areas were widely distributed and the different points of departure comparatively remote. Certain of the topographical assistants, too, were inexperienced; yet, notwithstanding all this, and the multitude of physical obstacles constantly in the path of each one of the parties, the area covered has been notably large, and almost equal to that of the season of 1871, when it was principally by reconnoissance-methods that the results were obtained.

It has been alone due to the untiring vigilance of the officers in charge and the industry of the several topographical assistants that the material for the important contributions to the geography of so large a part of our western interior has been gathered.

METEOROLOGICAL BRANCH.

The general method of the previous seasons has been followed during that of 1873. Hourly observations have been taken at the primary astronomical stations with the cistern-barometer, psychrometer, and anemometer. As many cistern-barometers, aneroids, and psychrometers as could be used to advantage have been distributed among the different ent field-parties, and a system of observation has been so adapted to camps, triangulation, topographical, and other stations, as to insure the determination of the greatest possible number of altitudes. The record of all these observations, up to the close of the field-season of 1873, has been transcribed upon computation-sheets, corrected and reduced, and the computation of altitudes is going forward.

It is proposed to group these altitudes, in accordance with the main topographical features of the country, in tables, which will appear in volume 3 of the series of publications.

The contents of this volume will be—

1st. A synopsis of the general plan for meteorological observations, the methods of reduction and computation, and the application of the results.

2d. The tables of altitudes, with general description of the locality of each group.

3d. Contour-maps of the atlas-sheets, with the curves at such intervals of altitude as are warranted by the results in barometric hypsometry, in conjunction with the elevations and vertical distances determined by the topographers.

4th. Tables and plates deduced from the hourly observations at the astronomical stations. These will comprise the abnormal and horary oscillations, and the changes in temperature and humidity of the atmosphere, with their effect upon the mercurial column.

With these will be published all facts that have been observed concerning the climate and climatal oscillations, with a description of the physical geography of the region of territory surveyed.

This branch of the survey is indebted to the cordial co-operation of the United States Signal-Service.

It has not been practicable, with the limited force that could be employed in working up the meteorological observations, to prepare this matter for publication; but, as time can be spared from other branches, this will gradually be brought forward.

Being an auxiliary to the other branches of the survey, it is in all respects subordinate to, and most of its results incorporated with, them.

GEOLOGICAL BRANCH.

Four professional geologists have, for different periods, been employed to accompany the several geographical parties and examine the structure of the region traversed. Of these, Mr. G. K. Gilbert was engaged in 1871, and has continued with the survey up to the present time; Mr. A. R. Marvine was employed during a portion of the first year only; Mr. E. E. Howell during the second and third, and Prof. J. J. Stevenson during the third year.

In 1871, Mr. Gilbert traveled mostly with the main field-party, crossing portions of Nevada, California, and Arizona, and making the voyage of the Colorado. Mr. Marvine, who spent but two months at geological work, began his observations at St. George, Utah, and continued them, via Prescott, Camps Verde, and Apache, to Tucson, Ariz.

The succeeding year, Messrs. Gilbert and Howell were employed principally in Western and Southern Utah; but their examinations also reached into Eastern Nevada and Northern Arizona.

For the greater portion of the season Mr. Gilbert accompanied Lieutenant Hoxie, and Mr. Howell the main division; but, upon the return-march, Mr. Howell joined Lieutenant Hoxie's party, while Mr. Gilbert was detached, and traveled alone by way of the valley of the Sevier to the final rendezvous at Salt Lake City.

In 1873, Mr. Howell accompanied Lieutenant Hoxie throughout the season, spending the earlier portion of it in Southern Central Utah, and the latter in Western New Mexico; Mr. Gilbert traveling with divisions of the main party in New Mexico and Eastern Arizona, and Professor Stevenson with the party commanded by Lieutenant Marshall in Colorado.

In all cases the geologists were assigned to separate topographical parties, and their routes arranged, so as to give them opportunity to acquire the most comprehensive ideas of the character of the country, and to obtain the fullest collection of data in a little-known region.

To get a right understanding of the results of their work, it is necessary to appreciate a broad distinction that exists between two regions

of country that were entered. Almost the entire region included between "the Plains" and the Pacific Ocean is mountainous; that is, the rocks which are its foundation are bent and broken and uplifted into ridges, which ridges are mountain ranges. But there is one exceptional area in which the beds of rock lie level, or nearly so, and this was named by myself in the year 1871 the "Colorado Plateau" region. In its general features, it contrasts very strongly with the surrounding mountain country. It consists of a system of tables, in places rising above each other in step-like order, and elsewhere divided by narrow, deep, and often impassable gorges. A large portion of this region is drained by the Colorado and its tributaries, but other parts send their waters to the Sevier Desert and via the Rio Pecos to the Rio Grande.

Of the political divisions, it comprises portions of Utah, Colorado, Arizona, and New Mexico, and its physical boundaries are the Uintah Mountains at the north, the Rocky Mountains at the east, and at the west and south the regions of the Cordilleras.

Through the labors of the topographers and geologists, the general dimensions of this area are now for the first time known, and its western, southern, and southeastern boundaries, making a line 900 miles long, are drawn on the map.

Within it are exceptional opportunities for the study of certain special geological subjects, and to these their attention has been turned. One of them is that of erosion by running water, which finds its superlative expression in the cañons of the Colorado, and is there contrasted with erosion by rain and compared with erosion by drifting sand.

Another subject is that of the origin of mountains; for, although the plateaus are distinctively not mountains, they contain certain simple dislocations which are the germs of mountains, and bear the same relation to dynamical geology that embryos bear to biology. These dislocations are faults and simple folds, and they have been traced and studied for hundreds of miles.

Another subject to which great attention has perforce been given is that of volcanic phenomena.

Every State and Territory west of the plains, every physical division the Rocky Mountains, the Plateaux, the Cordilleras, are crowded with the products of volcanic action, ancient and modern. Hardly a mountain range lacks them.

The largest consecutive areas without them are among the plateaux; but in that same province, also, are some of the largest lava-fields.

In Southern Utah there are connected floods of lava, covering an area of 5,000 square miles; and of this area the geologists of the expedition have obtained data for geological maps.

They have also approximately defined the limits of a similar area in Arizona and New Mexico not less than 20,000 square miles in extent, and never before recognized as a connected belt.

Of the conclusions which they draw from their accumulation of volcanic data, one, at least, is of general interest, namely: that eruptions in our western territory will be again resumed, which occurrences may take place at any time. In the past, they have occurred so recently that it is, indeed, surprising that there is no human record of them.

The distribution of the geological formations has been made out with a good degree of accuracy in the portions of the plateau country and Rocky Mountains that have been examined; but in the region of the Cordilleras less has been accomplished, for the reason that all relations there are more complicated and no strata can be traced continuously for great distances. Among the contributions to stratigraphical knowledge are the determination of the Tertiary age of the Sam Pitch coals of

Utah, of the Cretaceous age of the coals of Castle Valley and Southern Utah, and of the Cretaceous age of the disputed coal-series of Colorado. Tertiary, Cretaceous, Jurassic, Carboniferous, and Silurian rocks have been identified by fossils in Utah, and all of these but the Jurassic in New Mexico; in Colorado and Arizona, Cretaceous, Carboniferous, and Silurian; in Nevada, Jurassic, Carboniferous, and Silurian; and in Southern California, Carboniferous and Silurian.

The age (heretofore in doubt) of the shale and sandstone at the base of the series of strata exposed in the Grand Cañon of the Colorado has been ascertained to be primordial.

Of special subjects of study, one of the most interesting has been that of the glacial epoch. The southern limit of the ancient system of glaciers has been ascertained through the entire extent in longitude of the survey, and an attentive examination has been made of the record of an expansion of Great Salt Lake, which occupied the valleys of Utah, while its highest mountain-gorges were choked with ice.

The elaboration of these results into reports for publication has occupied the geologists during the winter-months.

The report of Mr. Marvine is in manuscript, ready for the press, and the same may be said of the report of Mr. Gilbert for the field-work of the seasons of 1871 and 1872, and of that of Mr. Howell. A portion, however, of the notes of the latter gentleman have been put into the hands of Mr. Gilbert to combine with some closely-related examinations of his own, and embody in the report, upon which he is now engaged, of his examinations in 1873.

Professor Stevenson has completed and submitted his report, with the exception of a single chapter. The whole will fill, when printed, about 350 quarto pages.

In the preparation of these reports, the itinerary form, so easy to write, but so inconvenient for use, either by the general reader or by the future student in the same field, has been avoided, and all the material presented has been thoroughly classified. Facts of common character have been brought together, and where their importance warranted, have been briefly discussed in their relations to each other and to cognate facts in other fields; and it is believed that the arrangement is such that the various data will be *readily* accessible to those who shall have occasion to use it.

An atlas of geological maps is in preparation, to accompany the reports.

The general facts of rock-distribution are to be indicated by colors laid upon the topographical-atlas sheets, and special maps will be constructed to illustrate some other features, such as the distribution of glacial phenomena and of thermal springs.

The illustrations with the text will consist of fourteen plates, derived chiefly from photographs of peculiar geological features, and of a large number of wood-cuts, the major part of which are now drawn.

The wood-cuts are chiefly diagrams and sections representing rock-structure, and are strictly explanatory of the text.

The geological collections (without including the fossils and ores) number 2,700 specimens. One of their chief uses has been already subserved in enabling the geologists to study, during the preparation of their reports, peculiarities of texture and composition that could not receive full attention in the field; but a larger portion of them have a permanent value also as material for special lithological study.

It is hoped that at some future day the volcanic rocks, which outnumber all others in the collection, can be placed in the hands of a competent specialist for study.

PALEONTOLOGY.

The fossils number 4,500 specimens, and come from all portions of the area examined. They have had their first (geological) use in identifying the several formations in a great number of localities, and promise to reward richly their paleontological study. A preliminary examination has been made of the invertebrates by Mr. F. B. Meek, the paleontologist, and upon his judgment an estimate has been made of 150 quarto pages of text and 30 plates for the description of the new forms.

The vertebrate remains, including bones of mastodon, horse, camel, rhinoceros, &c., have been submitted to Prof. O. C. Marsh, who will report upon them.

The collections were made by the geologists and mineralogists of the expedition, and by Assistant George M. Keasby, who accompanied one of the parties in New Mexico in the last season with the special errand of gathering vertebrate remains.

MINERALOGY.

During the field-season of 1871, Acting Assistant Surgeon W. J. Hoffman accompanied the expedition as naturalist and mineralogist, and in 1873 Dr. O. Loew joined the survey as mineralogist and chemist.

Besides the collections of these gentlemen, a great many specimens of minerals and especially of ores have been gathered by the officers in charge of parties and by the geologists.

The entire accumulation numbers 1,600 specimens. Dr. Loew has prepared a report to be included in the geological volume, comprising, with a *résumé* of the results of previous years, a full account of his chemical and other investigations. It is now ready for the press, will fill 45 pages, and includes—

1. A report on the agricultural capacities and lands of portions of New Mexico and Arizona, with notes on the geographical distribution of plants, and on several cosmical phenomena.

2. The analyses of all mineral springs encountered, of saline efflorescences and incrustations; also analyses of soils and plants, of coal-specimens, ores, kaolins, and of a fossil resin hitherto unknown.

3. A description of the volcanic rocks of New Mexico and Arizona, with numerous analyses. In some of these rocks, cobalt and nickel were found, an occurrence heretofore not observed.

4. Tables comprising the minerals collected, their occurrence in Nevada, Utah, Arizona, New Mexico, and Colorado. These comprise the collections of the last four years, and are arranged after the chemical system of Professor Dana.

Numerous mining-districts in Colorado and New Mexico were visited, the ores and their geological occurrence described, and specimens collected.

In Colorado, especial attention was paid to the mines of Gold Hill, Central, and Georgetown.

The predominating ores of Gold Hill are the tellurides of gold, silver, and lead; those of Central, auriferous pyrites; those of Georgetown, argentiferous galena.

The principal gold-mines of New Mexico are situated in the Placer Mountains, 30 miles south of Santa Fé, where the precious metal is found free in placers as well as in iron-pyrites.

The chief silver-mines noted in this Territory are those at Silver City and Fort Bayard, where chloride of silver occurs in gypsum and slate,

associated frequently with cerassite, galena, and malachite. These ores are chiefly deposits, no true fissure-veins having as yet been developed. Similar ores occur on the Sierra Madalena, (Socorro mines,) together with frequent deposits of argentiferous cerassite.

True fissure-veins of argentiferous galena occur at La Joya on the Rio Grande Extension, and valuable copper-mines are worked in the Burro Mountains, at Santa Rita, and on the Rio San Francisco in Arizona.

Silicate, carbonate, red oxide, and sulphide of copper are the principal forms in which the copper is encountered. Colorado and New Mexico abound in mineral springs. These springs may be classified, as to their thermal conditions, into hot and cold, or, according to their prominent compounds, into soda, iron, salt, sulphur, lime, and siliceous springs.

Hot salt-springs occur on the Rio San Francisco in Arizona; hot lime and soda springs at Ojos Calientes on the Jemez Creek, New Mexico; cold soda springs at Cañon City, Col.; iron springs on the Arkansas River (Carlisle), and in the Greenhorn Mountain Range a sulphur-spring.

Spectroscopic investigations have always been combined with the analysis, and thus the presence of lithia was detected in most of the classes of springs above mentioned.

NATURAL-HISTORY BRANCH.

The force at disposal has been directed with a view to the accomplishment of the largest possible results, which have proven entirely satisfactory.

Considering the character and extent of the area entered, the attendant expense has been comparatively small.

The subjoined report from Acting Assistant Surgeon H. C. Yarrow, U. S. Army, sets forth the objects, operations, and results more fully.

REPORT OF ACTING ASSISTANT SURGEON H. C. YARROW, U. S. ARMY.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS
WEST OF THE 100TH MERIDIAN,
Washington, D. C., June 30, 1874.

SIR: I have the honor to submit the following brief *résumé* of the results of operations in the branch of natural history of the survey under your charge, during the past year, introducing incidentally facts bearing upon the results of the two previous years.

Such a sketch would appear particularly desirable at this time, since as yet, excepting in two instances, the natural-history branch has been unable to publish either notes or descriptions of the specimens collected and studied during the period in question, notwithstanding many hundred pages of manuscript have long been prepared.

The general plan for studying the natural history of the Western Territories has been to collect everything calculated to throw any light on the subject and add to our somewhat limited knowledge of the geographical distribution of animals and plants, and afterward to submit such collections to specialists for study, and a report of the results of their investigations; the specimens finally being presented to the National Museum at the Smithsonian Institution, by which establishment they are distributed to different institutions of a similar character throughout the world.

For the last-mentioned reason, therefore, especial attention has been directed to procure duplicates, in order that, instead of our industry appearing selfish, numbers of learned institutions might partake of the knowledge thus acquired.

Some years since it was held that the possession of scientific acquirements should be only for a favored few; but at the present day more thorough systems for the dissemination of scientific knowledge have been inaugurated.

To the corps under whose auspices this expedition was projected, and is still carried on, is due, to a great degree, the popularization of the study of natural history in this country.

The operations of the natural-history branch of this survey may be briefly stated as follows:

In 1871, the services of Dr. W. J. Hoffman, U. S. Army, and Mr. Ferdinand Bischoff were secured, the former as surgeon and naturalist, the latter as collector, by whose joint efforts many hundreds of specimens were secured in zoology and botany, among which were quite a number hitherto unknown to science. Of this collection, the botanical portion was placed in the hands of Prof. Sereno Watson, of Cambridge, who kindly named the new species, and submitted a report upon the collection, which has been received, and will prove a valuable contribution to our knowledge of the flora of the interesting section of country visited.

The mammals collected have been reported upon by Dr. Hoffman; the birds, by Mr. Ridgway of the 'Smithsonian,' Mr. Henshaw, and myself; the reptiles and fish, by Prof. E. D. Cope and myself; and the insects, of which many thousands were secured, by Mr. Ulke, Professor Thomas, Professor Uhler, and others. In addition to those received at this office, many other specimens were collected, which, however, unfortunately, were either lost in transit from the West or destroyed in the great Chicago fire.

The collection of 1871, while not as large as either that of 1872 or 1873, is extremely interesting, from the fact that many of the rarer forms of zoological life were met with as well as important data obtained relative to their general distribution and occurrence. This entire collection has been deposited in the National Museum.

In 1872, recognizing the great value of the collections already made by the Engineer Corps of the Army, and being assured that to the scientific world researches in natural history, especially on our western frontier, would add greatly to our knowledge of the zoology of that region, you permitted unusual facilities for the prosecution of such labor, the results proving the wisdom and foresight of such a course, since a collection was made seldom rivaled by that of any similar expedition having but two collectors.

It is but proper, however, to add that several of the members of the survey contributed largely to the general stock of specimens.

In this collection there were about eight hundred bird-skins, most of them rare and valuable; a large number of mammals; several hundred fish, of which no fewer than sixteen species were new to science; and many reptiles, insects, shells, plants, &c., embracing in all probably 5,000 specimens. Not the least important specimens in the collection were a number of Indian crania, obtained at considerable risk from the Ute burial-places and ancient mounds in the valley of the Great Salt Lake, as well as numerous implements, both ancient and modern, used by the aborigines.

This entire collection has been apportioned among eminent special-

ists for determination, most of whom have already reported, their manuscripts awaiting publication.

The mammals have been identified and reported upon by myself: the birds, by Mr. Henshaw and myself, with the assistance of Mr. Ridgway, of the Smithsonian Institution; the reptiles and fishes, by Prof. E. D. Cope and myself; the insects, by Mr. Ulke, Professor Uhler, Professor Cresson, Dr. Hagen, Baron Osten-Sacken, Professor Thomas, and Mr. Edwards; and the shells by Mr. G. W. Tryon, jr., of the Philadelphia Academy of Natural Sciences.

The botanical collection has been worked up by Prof. Sereno Watson, of Cambridge, who had charge of, and reported upon, the collection of 1871.

The Indian crania have been forwarded to the Army Medical Museum, and we are assured by the officer in charge that the donation is a valuable one.

In 1873, the natural-history party was enabled to take the field early, and, through the indefatigable exertions of the collectors, results were secured even exceeding those of the previous year; the official record showing the following number of specimens:

"Seven Indian crania.
"One hundred and sixty mammals.
"One thousand and two hundred bird-skins.
"Five hundred birds eggs.
"Twenty-five birds nests.
"Fifty birds crania, skeletons, and sterna.
"One hundred and forty-five reptiles.
"Five hundred and five fish.
"Five hundred beetles, (*Coleoptera.*)
"One hundred and fifty butterflies, (*Lepidoptera.*)
"Five hundred grasshoppers, (*Orthoptera.*)
"Thirteen lots of flies, (*Diptera.*)
"Thirteen lots of bugs, (*Hemiptera.*)
"Twelve lots of worms, leeches, larvae, &c.
"Seven lots of ants, (*Formica.*)
"Fifty-five lots of shells, land and fresh-water.
"Twenty-four lots of dragon-flies, (*Neuroptera.*)
"Twenty-eight lots of bees and wasps, (*Hymenoptera.*)
"Twenty-six lots of spiders, scorpions, &c., (*Arachnida.*)
"Fifteen thousand plants, embracing at least one thousand and five hundred species."

This collection contains many new as well as many rare species, seldom to be found in public museums. As in former years, the plan has been continued of distributing the specimens to eminent scientists, and from the majority of these gentlemen reports have already been received and are now ready for printing.

Thanks are due to the following gentlemen, who have so kindly aided in many ways, in every case giving their valuable services gratuitously to the elucidation of scientific material connected with the expedition, viz: Prof. Joseph Henry, Prof. S. F. Baird, Prof. E. D. Cope, Prof. S. A. Allen, Prof. A. E. Verrill, Prof. O. C. Marsh, Dr. H. Allen, Dr. H. Wood, jr., Dr. George A. Otis, U. S. A., Dr. J. J. Woodward, U. S. A., Prof. A. Agassiz, Dr. H. A. Hagen, Mr. W. H. Edwards, Mr. Theodore L. Mead, Dr. P. H. Uhler, Mr. H. Ulke, Prof. Cyrus Thomas, Prof. Townend Glover, Mr. Robert Ridgway, Mr. G. Browne Goode, Prof. E. T. Cresson, Mr. W. G. Binney, Mr. G. W. Tryon, jr., Prof. Sereno Watson, Mr. George Thurber, Prof. Thomas. P. James, Dr. George Vasey,

Baron Osten-Sacken, Mr. G. N. Lawrence, Mr. Thomas Bland, Prof. S. Olney, Mr. R. H. Stretch, Mr. Aug. R. Grote, Dr. William Holden, Mr. Edward Norton, Dr. Elliott Coues, U. S. A., Prof. Asa Gray, Mr. J. H. Milner, Dr. A. S. Packard, jr., Mr. S. C. Scudder, and others.

In conclusion, I beg leave to express thanks for the great interest manifested in this branch of the work committed to your charge as well as for the facilities you have always afforded for making collections.

With the hope that, as in the past, the future may find you alive to the importance of the natural-history wants of the period, I have the honor to be, very respectfully, your obedient servant,

H. C. YARROW,
Surgeon and Naturalist to Expedition.

Lieut. G. M. WHEELER,
Corps of Engineers, U. S. Army.

PHOTOGRAPHS.

As heretofore, a photographer has accompanied the expedition, following a route from Santa Fé westward, via Fort Wingate; thence to Camp Apache, and the vicinity of the Sierra Blanca range, Arizona; thence northward, *via* old Fort Defiance, Moquis Pueblos, and the Cañons of the Colorado.

A great variety of negatives, of which a few prints have been taken, were secured, illustrative of natural scenery, the habits and customs of the Indian tribes, ancient ruins, &c.

During the season, the executive officers of parties have gained valuable experience in the subjects of observation intrusted to their charge.

The property, purchasing and disbursing branches have been faithfully and efficiently filled by Assistants Francis Klett and George M. Lockwood.

OFFICE.

While the expedition of 1873 was in the field, three draughtsmen and one computer were employed in the office, and completing results to the close of the season of 1872, both topographical and meteorological, and those of 1873 are well advanced.

The great mass of geographical information obtained annually obliges this method, which proves to be most economic.

CONCLUSION.

The progress and improvement of the survey have passed through successive stages since its commencement in 1869. It is believed that in its present efficient state it answers a want of the War Department and the country, and has at its foundation a judicious economy.

The results are available to other executive departments of the Government than the War Department, and incidentally to the industries of the region surveyed. While suggesting the propriety of the continuance of the survey, a few of the many classes of information are here noted, the results from which are believed to be of constant necessity and usefulness in the War Department:

1st. The published maps, profiles, and compiled distances over present and future routes of communication and supply that look to a saving in cost of transportation of all materials and munitions of war and other supplies forwarded through the Quartermaster's Department of the

Army. As a correct understanding of the topographical features of a country is necessary to all military operations, either in times of war or peace, the necessity for the acquisition of this information in a systematic form at the War Department, and its dissemination through the different branches of the military service, becomes apparent.

2d. The establishment of routes of communication necessary for the supply of interior posts. For an understanding of the above, the interlying country requires thorough examination.

3d. Critical routes to be followed in the interchange of troops between distant stations when demanded.

4th. New and shorter routes for forwarding recruits to their companies and stations.

5th. Routes for scouts pursuing hostile or unfriendly Indians.

6th. The selections of sites for new military posts established in advance of, or as safeguards to, civilization.

7th. Routes for troops when called out for the protection of miners or settlers.

8th. A knowledge of the resources of the country surrounding the military establishments, and its capacity for furnishing supplies.

9th. Routes of transit when troops are ordered to remote points in aid of the civil law.

10th. A knowledge of the character and habits of the several Indian tribes, and their disposition toward each other and toward settlers.

The above are a few of the classes of examinations necessary and valuable to the several Bureaus of the War Department and to the commanders of troops in their pioneering into the unoccupied and comparatively inaccessible portions of the western interior.

To obtain such information that should be at all times immediately available for the uses of the War Department, such observations as are necessary for an *accurate delineation and description of the surface and resources of the area surveyed* must be made. This calls for geographical surveys in their highest and broadest sense.

The position of the cognate branches of science in carrying on so important a work must naturally be subservient to the exact science necessary to the delineation of the surface with accuracy. Meanwhile, the co operation of specialists in the branches above referred to will, without largely increasing the cost, enhance that portion of the results relating to the resources of the region surveyed, and to them the best facilities for the prosecution of their inquiries are afforded, as also most excellent opportunities for the proper application of their results.

In order that the survey may be continued at the standard proposed in the Progress Report for 1872, the estimate below submitted will be required to be appropriated, so that one of the units of force may take the field, and within the year, or shortly thereafter, publish its entire and complete results.

The survey is capable of expansion to meet the wants of the Government, but its operations cannot be made satisfactory except at least one of the units of force is appropriated for.

The law for the present year admits of the prosecution of the survey with the force at its disposal in any portion of the area west of the one hundredth meridian.

The special area for the season of 1874 has been authorized by the War Department.

Of mountainous areas very little known, whose present and prospective mining developments indicate that this industry will soon enter them, are portions of New Mexico, represented by that part of atlas-rectangles 77, 84, 78, and 85, west of the Rio Pecos and east of the Rio

Grande; also, in rectangles 47, 48, and 57, and portions of 65, along the east base of the Sierra Nevada range.

It is not deemed essential or advisable to have limited long in advance special areas to be occupied in any one year, although, so far as practicable, the areas of several years should be made to conjoin, yet the survey should be held as an intact organization, prepared to carry on its work in any portion of the interior west of the one hundredth meridian into which it shall be ordered by the War Department.

As the surveys of the General Land-Office are being extended into the mountainous mining-districts, and as there are boundary-lines between political divisions yet to be marked, I would suggest the propriety of an interchange of results between the General Land-Office and this survey.

The use of details of the former prevents the necessity of duplication of work in certain valley-areas, while points could be furnished checking standard meridians and bases, prominent points on boundary-lines, initial points for the surveys of mining claims and areas, &c.

The amount required for the prosecution of the field and office work of the survey for the fiscal year ending June 30, 1876, by the unit of force proposed, is $95,000. No less sum than this can be used with the same resulting degree of economy.

The probable distribution of expenditures under this appropriation would be as follows:

Expense of nine parties in field and office	$58,000
Transportation, including purchase of animals	8,500
Purchase of materials, outfits, &c	6,500
Subsistence of parties in the field	6,400
Forage, including winter-herding	7,500
Repairs of instruments	1,500
Office-rent, fuel, storage, &c	3,100
Contingencies, including erection of monuments and observatories at astronomical stations	3,500
Total	95,000

Amount appropriated to continue explorations and surveys west of the one hundredth meridian for the fiscal year ending June 30, 1875	$30,000 00
Amount allotted from balances existing June 30, 1873, and made available by act approved June 23, 1874	60,000 00
Amount remaining on hand at close of fiscal year ending June 30, 1874	25,889 45
Amount required for field and office for fiscal year ending June 30, 1876	95,000 00

All of which is respectfully submitted.

GEO. M. WHEELER,
First Lieutenant Corps of Engineers, in charge.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. Army.

F F 2.

PLAN FOR PUBLICATION OF REPORTS AND MAPS, WITH ESTIMATES.—SUMMARY OF PUBLICATIONS TO PRESENT TIME.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS
WEST OF THE 100TH MERIDIAN,
Washington, D. C., June 30, 1874.

GENERAL: The estimate of $95,000, submitted as the amount necessary to continue the work under my charge for the fiscal year ending

June 30, 1876, covers the expense only of the field and office work of the survey, but not the publication of maps or illustrations for the survey-reports.

In the act approved June 23, 1874, the amount of $25,000 was appropriated for the fiscal year ending June 30, 1875, for illustrations for the volumes to be published.

The greater number of the manuscripts for the six volumes proposed (see Annual Report of the Chief of Engineers for 1873, p. 1717) are ready for the press, and only await the preparation of the illustrations for the same, which will be begun early in the coming fall.

The necessary changes, in the manner proposed in the last annual report, for the form and scope of the volumes are as follows: Volume 1 is to include the general report of 1873, and condensed reports upon all the mining-districts visited since the year 1871. It should be complete soon after the return of the expedition of 1874. Volume 2 is to include reports upon the astronomical stations of 1873. The manuscript will be ready for the press as soon as the observations necessary for the connection of the astronomical observatory at Ogden, Utah, with the U. S. Naval Observatory at Washington, D. C., are computed. Volume 3 is to embrace the subjects proposed in the annual report of this year. It is somewhat doubtful whether it can be published during the present fiscal year. Volume 4, as indicated in the main body of the report, approaches completion, and ought to be ready for the press by October 10. The examination of fossils and the preparation of reports upon paleontology are going on while the parties are in the field, and ought to be well advanced by the 1st of October. This volume will also contain a report upon the vertebrate fossils collected in 1873. Manuscript reports for volume 6 are nearly ready, and can go forward to the printer during October.

It has been found impossible to include in the present annual report total results up to date in the astronomical, meteorological, and topographical branches, as stated in my last annual report. They are all brought closely to completion, however; and the reports relating to the cognate branches of the survey, as therein indicated, will be hereafter brought out in special form.

The present field-season must necessarily be a short one, and during the coming year it is deemed possible to establish a complete harmony between field and office work and results so that, as nearly as possible, within the fiscal year, the final results shall be placed in publication-form.

PUBLICATIONS.

Since the inception of the work under my charge, the following separate publications other than maps relating thereto have appeared: Preliminary Report, 1869, (octavo;) Preliminary Report, 1871, (quarto;) Table of Camps, Distances, &c., 1871 and 1872, (quarto;) List of Mining-Questions; List of Mining-Districts Visited, 1871, 1872, and 1873; Landscape and Stereoscopic Views taken in the years 1871, 1872, and 1873; Preliminary Report upon the Fishes, 1871 and 1872, by Prof. E. D. Cope, (pamphlet;) Annotated List of the Birds of Utah, collected in 1872, (pamphlet.)

The following reports have been submitted to the Engineer Department, with a request for their publication, and it is believed have gone forward to press: Progress Report, 1872; Report upon the Botanical Collections of 1871, 1872, and 1873; Report upon the Ornithological Collections of 1871 and 1872.

A Report upon the Determination of the Astronomical Co-ordinates of the Stations at Cheyenne, Wyoming, and Colorado Springs, Colorado, quarto, was issued in January, 1874.

MAP-PUBLICATIONS.

Topographical atlas. — An advanced-sheet issue of this atlas has been photolithographed during the year. It contains (1) title-sheet, (2) legend-page, (3) basin-chart, (4) progress-map, and sheets Nos. 50, 58, 59, and 66. A 2,000-copy edition has been published, and 486 sets distributed; 500 copies of sheets Nos. 50, 58, 59, and 66 have been printed on thin paper for preliminary distribution.

Proofs have been presented of sheets Nos. 50, 59, and 66, executed by the crayon-process. No. 59 is within a few days of completion. In addition, there are in the hands of the lithographer, of which proofs are to be furnished soon, (1) index-map, (2) general topographical map of the area west of the Mississippi River, and (3) an explanation-sheet. Sheets 49 and 67 are in an advanced state of preparation, and go forward soon to the lithographer. Sheets 57, 65, 75, 76, 83, and portions of 77 and 84, are in process of construction on a scale of one inch to eight miles. The southeastern, northeastern, and southwestern parts of sheet 61, and the southeastern quarter of sheet 52, are being constructed on a scale of one inch to four miles.

All of the sheets above mentioned will doubtless be completed and published during the coming year. The several photographic copies of the preliminary maps for office-use are printed by the photographer of the expedition. There have been made, during the year, issues of the preliminary maps of 1869 and 1871 and of the office-map of 1872.

There is a large and increasing call for maps of the comparatively unknown regions west of the one hundredth meridian, and the edition already authorized will be insufficient to meet the wants of the present fiscal year. The atlas of geological maps is referred to in the main body of the report. From material gathered, fourteen sheets are proposed for publication.

The following estimate for the publication of maps and illustrations for the reports is submitted for the fiscal year ending June 30, 1876. The amount is the same as that appropriated for the present fiscal year.

For preparation, photolithographing, engraving, and printing atlas and other topographical maps, including the field-work of 1874	$15,000
For preparation, photolithographing, engraving, and printing geological maps, to include the work of the field-season of 1873	2,500
For engraving and printing plate and other illustrations for reports	7,500
Total	25,000

The amount appropriated for engraving and printing illustrations for the reports of explorations and surveys west of the one hundredth meridian, for the fiscal year ending June 30, 1875, is $25,000.

Amount required for the preparation, engraving, and printing of topographical and geological atlas, maps, and illustrations for reports for the year ending June 30, 1876, $25,000.

A copy of the progress-map is herewith, showing approximately the areas surveyed up to the close of the field-season of 1873.

Very respectfully, your obedient servant,

GEORGE M. WHEELER,
First Lieut. of Engineers, in charge.

Brig. GEN. A. A. HUMPHREYS,
Chief of Engineers, U. S. Army.

APPENDIX FF 3.

REPORT ON PALEONTOLOGY.

UNITED STATES ENGINEER OFFICE,
EXPLORATIONS AND SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., October 15, 1874.

GENERAL: I have the honer to forward herewith a special report received from Prof. E. D. Cope, paleontologist to the expedition of this season, embodying some of the results of his labors in portions of New Mexico, up to the 27th of September. This report contains new and valuable information relative to vertebrate fossil remains.

Very respectfully, your obedient servant,

GEO. M. WHEELER,
Lieutenant of Engineers, in charge.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. Army.

REPORT OF PROF. E. D. COPE, PALEONTOLOGIST.

CAMP ON GALLINAS CREEK, *September* 27, 1874.

SIR: In accordance with your instructions to forward a report of proceedings, I beg leave to state that I returned to this camp from Tierra Amarilla on the 15th of the month, and have remained here ever since. We have been mostly employed in examining the bad lands of the Eocene of the divide between the Chama and San Juan Rivers, and in collecting the vertebrate fossils which their beds contain. A little time has been devoted to the Cretaceous beds forming the rim of the Basin. From the Eocene beds, more than seventy-five species of vertebrates have been obtained, many of which are new to science, and others are largely illustrated by additional remains. Four species of a new order, the *Toxodontia*, have been discovered, and our knowledge of the structure of other peculiar forms enlarged. Interesting relations between the Cretaceous and Tertiary beds have been observed.

Mr. Shedd has been assisting in making collections and taking his meteorological observations at the stated times.

The health of the party continues good, and we hope to move camp to another point ere long.

Very respectfully, your obedient servant,

EDW. D. COPE,
Paleontologist.

Lieut. GEO. M. WHEELER,
Corps of Engineers, U. S. A.

NOTES ON THE EOCENE AND PLIOCENE LACUSTRINE FORMATIONS OF NEW MEXICO, INCLUDING DESCRIPTIONS OF CERTAIN NEW SPECIES OF VERTEBRATES, BY PROF. E. D. COPE, PALEONTOLOGIST TO THE EXPEDITION.

PART I.

One of the results of the examinations made during the field-season of 1874 is the discovery of an extensive series of deposits of Eocene age. These indicate the existence, during early Tertiary time, of an extensive lake of fresh water in that part of New Mexico now drained by the tributaries of the Chama River on the east and the San Juan River on the west. This lake received the remains of the fauna of its shores and other regions adjacent, which have been preserved and obtained by the members of the expedition detailed by Lieutenant Wheeler for its investigation, in considerable numbers.

The shore of this lake was formed by rocks of the Cretaceous formation of an age near the No. 3 of Meek and Hayden. In approaching it from the east, we traverse the sandstones of Cretaceous No. 1, both horizontal, and tilted at various angles, and find No. 2 resting upon it frequently unconformably, and tilted at higher angles, fre-

quently 45°, sometimes 50°, to the west and southwest, and containing numerous fossils, as *Inoceramus*, etc. The upper sandstones of this formation pass into a brackish or fresh-water formation, which includes a bed of lignite, of sometimes 50 feet in thickness. Above this rests, conformably where seen, a moderate thickness of rather soft marine rocks, containing numerous shells, *Acephala*, *Gastropoda*, and *Cephalopoda*, including *Oysters*, *Baculites*, and *Ammonites* resembling *A. placenta* most, with sharks' teeth. Resting unconformably on these, with a much reduced dip, is a mass of brown and reddish sandstones, some 1,500 feet in thickness, inclining perhaps 10° south and southeast. These pass continuously into the superincumbent red and gray marls, alternating with brown and white sandstone of the fossiliferous beds of the Eocene. The observed part of these beds is about 1,500 feet in depth.

A considerable number of species of *Vertebrata* have been obtained, a large majority of which are *Mammalia*. While it is premature to attempt to determine fully the character of the fauna, enough has been ascertained to indicate marked differences from that of the Bridger group of Wyoming. It is peculiar in the entire absence of the genus *Palæosyopsos*, so characteristic of the former, and its replacement by *Bathmodon*, which has never been recorded from the Bridger formation. The abundant species of *Hyrachyus* of the Bridger are here represented by a single one of small size, which occurs but rarely, while its companion, *Hyopsodus*, is very rare or wanting. While gar-remains are abundant in both, the *Amiidæ* and *Siluridæ* have not yet rewarded our examinations. The characteristic genera of the New Mexican fauna are *Bathmodon*, Cope; *Hipposyus*, Leidy; and *Phenacodus*, Cope, genera which it shares with the *Bathmodon* bed of the Green River formation of the Bear River Wyoming. There is in all respects so close a resemblance between these deposits as to lead to the belief in their horizontal identity, and with other reasons, to give to the southern basin a higher antiquity than belongs to the celebrated Bridger series. The interesting fact that the teeth of six or seven species of sharks and one *Ostrea* have been deposited with the mammalian remains indicates that the marine Cretaceous rocks formed the coast-material of this lake, and the earlier period of its deposit is probable on various grounds, to be considered at a future time. The facts are all confirmatory of the view already expressed by the writer that the population of the Bridger epoch was derived by migration from a southern region.

Perhaps the most important addition to paleontological science obtained during the course of the investigation is the discovery of four species of two new genera, *Calamodon* and *Ectoganus* of *Toxodontia*, an order which has not been heretofore identified as having existed on the North American continent.

DESCRIPTION OF SPECIES.

ECTOGANUS GLIRIFORMIS, *gen. et sp. nov.*

Char. gen.—This genus rests on a number of remains of the crania of three species, ncluding principally teeth, in a good state of preservation, all found in appropriate relations by the writer. The teeth include incisors, molars, and premolars, it is believed, of both superior and inferior series.

There are two types of gliriform incisor-teeth, and of one of these in the largest species three sizes. In the one, the teeth are elongate, compressed, convex in both directions on the anterior; are convex or angulate in section at the posterior face. In all, the enamel is confined to a band on the anterior face, extending more or less on one side or the other, the naked dentine extending prominently backward at the middle and basal portion of the shaft.

In the larger size, this portion is subacute behind; in the smaller, obtuse. Teeth of this type are of three sizes, the smaller two the most compressed and with narrowest enamel. Those of the second type are of one, an intermediate size, and are shorter than those of the others and less compressed. One of their faces is concave in both directions, and is covered with enamel from the apex of the tooth for some distance posteriorly. From its terminus on the concave side, the enamel borders retire to the sides of the convex front.

There are three molars of the superior and many of the inferior series available for present determination. The superior are all remarkable for the great exposure of their external faces as compared with their internal, and the extension of the enamel on the outer face of the very thick external root, which is not distinguished from the crown. The true molar has three roots, and the crown is longer antero-posteriorly than transversely. It consists of two transverse tubercular ridges, connected by a medium oblique longitudinal ridge. The premolars have two of the roots connate, forming a support to the greater part of the crown. The worn surface is in form something like the Greek ω, the deep emargination being internal. The inferior molars have greater antero-posterior than transverse diameters. The enamel is more extended on one side than the other, covering the exposed portions of the roots. The grinding surface is plane, and has the form of a horizontal ϖ; the limbs being angulate, as in the Greek Σ.

It isimpossible to determine the affinities of this curious genus with the material

at present in my hands, but it is evidently nearer to the South American *Toxodon*, Owen, and *Typotherium*, Gervais, than anything yet discovered in the North American Tertiaries. It is no doubt related to the *Anchippodus*, Leidy, and *Tillotherium* Marsh, (which Marsh observes may be identical,) but differs from both in many points of the dentition.

Char. specif.—All the incisors are regularly convex in front. The surface of attrition of the large ones truncate, of the small ones oblique. The section of the large ones near the base is diamond-shaped, with one acute angle truncate and the other rounded. There are some shallow grooves on the sides, and on one side a more pronounced longitudinal shallow angulation. The enamel of these and of all the molars is smooth, and there are no cingula on the latter. The transverse crests of the unworn true molars support two tubercles, and the inner extremities of the crests of the premolars are produced in accordance with the oblique wearing of the incurved crown in mastication.

Measurements.

	M.
Length of incisor, largest, type 1	.043
Width of incisor, largest, type 1	.013
Depth of incisor, largest, type 1	.018
Length of incisor, medium, type 1	.034
Width of incisor, medium, type 1	.006
Depth of incisor, medium, type 1	.014
Depth (?) of incisior, last, type 1	.009
Width of incisor, last, type 1	.004
Length of incisor, type 2	.031
Width of incisor, type 2	.006
Diameter of crown of premolar { longitudinal	.010
Diameter of crown of premolar { transverse	.010
Length of enamel of face externally	.013
Length of enamel of face posteriorly	.005
Length of crown of posterior upper molar	.016
Width of crown of posterior upper molar	.012
Length of crown of posterior lower molar	.012
Width of crown of posterior lower molar	.009

Size about that of a fully-grown hog, (*Sus scropha.*)
Portions of several individuals have been found.

CALAMODON SIMPLEX, *gen. et sp. nov.*

Char. gen.—Molar teeth subcylindric, prismatic, rootless; the crown only distinguished by its investiture of enamel, which exhibits a weak marginal inflection for a portion of the length. Enamel extending in a band on one or both sides of the tooth to the base. Incisors rodent-like, curved, with a band of enamel on the anterior face, and obliquely-truncate extremity.

A number of specimens, probably representing this genus, have been found, and I select as typical those of an individual in which the molar and incisor teeth occurred together. The form is evidently allied to *Ectoganus*, as the close resemblance of the incisor teeth demonstrates, but the molars are of a much more simple type than anything yet discovered in this group, imitating superficially those of some *Edentata.*

Char. specif.—Molar (? superior) longitudinally bent, the convex (outer) face covered with enamel to the base. Enamel extending a much shorter distance on the inner face, and soon worn through by attrition on one of the other faces. Section of the base of crown a subquadrate oval. A slight inflection of enamel on the inner and a still weaker one on the (?)posterior border of the triturating face. Enamel with slight longitudinal ridges. Incisor much curved, strongly convex in transverse section, the enamel obscurely longitudinally ridged on both sides near the border. Section of one side slightly concave.

These and other specimens indicate an animal at least as large as the American tapir.

Measurements.

	M.
Length of a molar	.042
Diameter of the same	015
Diameter of incisor, transverse	.019

CALAMODON ARCAMŒNUS, *sp. nov.*

This *Troxodont* is represented by a portion of the skeleton of a specimen including several teeth, and most probably by portions of another, which includes a large and perfect inferior incisior-tooth. The former displays the alveoli for molars and incisors,

showing the one-rooted character of those of the lower jaw, and the deep implantation of the incisor below the antepenultimate molar. The number of molars indicated by the ramus is five, the antèrior in close contact with the single large incisor. The molars are subquadrate in section, the last a little longer than broad. The only one in which the crown is preserved exhibits a short crown, with its inferior enamel border notched on two, and oblique on two sides, and the external layer of the root swollen above it all round. The summit of the crown is worn, and is divided subequally by a transverse, rather shallow, groove. One division of the crown exhibits two dentinal areas in transverse line, the other three small ones in a curved line. The extremity of the curved incisor is rodent-like, and regularly convex on the anterior face and entirely smooth. The posterior or grinding face is convex in cross-section.

A large lower incisor of another individual is about five inches in length and one and a half in depth, without the increase of elevation of the superior or interior edge, as is seen in *Ectoganus gliriformis*. This edge is obtusely rounded, and instead of being obliquely leveled to meet the masticatory surface of the extremity, is abruptly truncate, the masticating face turning off at one side of the shaft. The enamel is smooth and of equal width and convexity throughout.

Measurements.

	M.
Elevation of crown of molar	.013
Length of crown of molar	.015
Width of crown of molar	.013
Diameter of incisor^{m}. 010 from tip	.013
Length of series of five molars	.090
Depth of jaw at third molar	.055
Thickness of jaw at third molar	.035

CALAMODON NOVOMEHICANUS, *sp. nov.*

Represented by a superior incisor-tooth of a species of smaller size than either of those already described, and differing in various respects from those of the *C. simplex*, of which a fine specimen has been obtained since it was first described. Both anterior and posterior edges are protected by a convex band of enamel; and the triturating surface is tranverse in the direction of the depth, and oblique in that of the width. The shaft increases in depth toward the root and is longitudinally concave on one face and convex on the other. The enamel bands are most extended on the convex face, and unite on that side round the triturating face and present an abrupt emargination on the middle of their convex border. The other, being formed of dentine only, is deeply worn by attrition.

Measurements.

	M.
Length of fragment	.038
Depth at fracture	.018
Depth at grinding face	.011
Width at grinding face	.009

This species differs from the supposed *C. simplex* in this incisor in other respects than in the smaller size. The latter is concave on both sides, and on the lower border; the former convex on one side, and on the lower border.

ESTHONYX BISULCATUS, *gen. et sp. nov.*

Char. gen. (?).—Incisors of two forms; the inferior subgliriform, but not growing from persistent pulps; the enamel covering a long and narrow external vertical face, and terminating above the alveolus, thus distinguishing crown and root. The other form of (?)incisor with the apex encased in enamel, but extending much farther on the outer than the inner side; the crown compressed, not wider than the root. Molars supporting two V's with rounded apices directed outward, the posterior soon wearing into a triangle lower than the anterior. The anterior elevated and transverse only distinguished from a triangle by a notch on the inner side. Last lower molar with this anterior transverse triangle, a diagonal ridge and a heel with raised border.

The type of this genus is *Ectoganus bisulcatus*, Cope, and a second species is *E. burmeisterii*, Cope. It differs from *Ectoganus* as well as from *Anchippodus* in the far less gliriform character of the incisor teeth, which may be compared with the extremities of the slender fingers of some monkeys with narrow nails.

Char. specif.—A species about the size of the *Capybara* is represented by the greater part of the dentition of the lower jaw, which includes representatives of both kinds of incisors already described under the characters of the genus. The rodent-like form is less typical of the genus than in the *E. gliriformis* in being rather shorter and furnished with a less extensive external enamel-plate. The dentinal column projects well internally, giving the tooth a regularly oval section. The incisor of the second form has the in-

ternal as well as the external enamel-face, and the former possesses a longitudinal angle bounding its concavity. The grinding-face of the molars and some of the premolars is ∞-shaped as in the other species, but the anterior limb of the figure is much thickened on the inner face, so as to have a triangular form, the base being inward. This base is notched by a second groove of that side of the tooth, which interruption is obliterated by prolonged attrition. This portion of the crown is elevated above the posterior, in consequence of the more rapid removal of the latter by trituration. The large internal and external grooves continue nearly to the base of the crown, as in the larger species. The last inferior molar is longer than the others, and is three-lobed, forming by its base nearly an isoceles triangle. The heel is formed by the backward production of the posterior convexity of the ∞, the central line of the figure forming a diagonal ridge across the middle of the tooth.

The mandibular ramus is of a deep compressed form.

Measurements.

	M.
Length of three consecutive molars	.0250
Length of last two molars	.0210
Length of penultimate molar	.0084
Width of penultimate molar	.0062
Length of last molar	.0112
Width of last molar	.0070
Length of incisor, second form	.0250
Diameter of incisor, second form	.0050
Diameter of incisor, first form, transverse	.0030
Diameter of incisor, first form, antero-posterior	.0070

ESTHONYX BURMEISTERII, *sp. nov.*

A species more nearly allied to the *E. bisulcatus* than to the type of the genus is represented by a portion of the right mandibular ramus, with the last molar tooth in perfect preservation. While the jaw is of depth similar to that of the *E. bisulcatus*, it is more slender in its proportions. The molar, also, while of nearly the same length, is relatively narrower, especially in its anterior portion. The crown of this tooth is worn in the specimen, and the anterior portion is elevated above the posterior, and displays a trace of the notch of the inner margin already observed in the species last described. The composition of the tooth is similar in other respects. No cingular; enamel smooth.

Measurements.

	M.
Length of last lower molar	.009
Length of last lower molar from anterior tubercles	.0060
Width { anteriorly	.0050
Width { posteriorly	.0025
Depth of ramus at last molar	.0240

This species is dedicated to Prof. Hermann Burmeister, director of the museum of Buenos Ayres, who has studied the group of *Toxodontidæ*, and given us an excellent account of their osteology.

ESTHONYX ACER, *sp. nov.*

Char. specif.—Established on a portion of the lower jaw, in which the last four premolars remain. They resemble those of the species already named, except in the anterior one of the series. This tooth in *E. acer* assumes the form of a premolar, the posterior V becoming a curved median cutting edge, and the anterior V opening into a crescentoid section; it rises to an acuminate apex, having thus a rather sectorial character. In the last three molars, there is a small tubercle at the inner base of the posterior limb of the anterior V. Posterior V much lower; enamel smooth.

Measurements.

	M.
Length of four last molars	.035
Length of three last molars	.026
Length of penultimate molars	.008
Width of penultimate molars	.005
Length of last molar	.011
Width of last molar	.005
Depth of jaw at last molar	.020

This species differs from the *E. bisulcatus* in the modified form of the last premolar; in the latter, it is relatively larger and more like the true molars. The last molar of *E. acer* is more like that of the *E. burmeisterii*, but the mandibular ramus of that species is relatively much deeper and similar to that of *E. bisulcatus*.

ESTHONYX MITICULUS, *sp. nov.*

Represented by portions of mandibular rami of three or four individuals of much smaller size than any of those referred to the species already described. There are represented two premolars and three molars; other teeth are lost. The molars differ from those of the three species named in lacking the notch or groove on the inner side of the anterior triangle of the crown, which constitutes it a V in those species, giving the worn surface a more simply sigmoid form; the anterior portion is, moreover, not materially more elevated than the posterior. The last molar has a large heel, an inner and two anterior tubercles when little worn. The premolars preserved are each two-rooted, the last is like the correponding one in *E. acer*, the penultimate without heel or inner tubercles.

Measurements.

	M
Length of three true molars, (No. 1)	.0120
Length of two last premolars, (No. 2)	.0064
Length of first true molar, (No. 1)	.0040
Width of first true molar, (No. 1)	.0030
Depth of ramus at first true molar, (No. 1)	.0080

The worn surfaces of the first and second true molars are much like those of the corresponding teeth of *Menotherium*, Cope. That genus differs in the reduced form of the last inferior molar and in the premolars.

MENISCOTHERIUM CHAMENSE, *gen. et sp. nov.*

Char. gen.—Molars three, with two continuous external crescents and two internal tubercles, except on the posterior, where there is but one, the anterior conic tubercle. The posterior tubercles on the other molars crescentoid in section. A well-developed crescent between the anterior tubercle and anterior crescent, and an oblique crest extending from the latter to the adjacent horn of the posterior inner tubercle. Two external crescents on the last premolar.

This genus presents a curious combination in the structure of its molars of the character of *Palæosyops*, *Hyopotamus*, and *Hipposyus*. It is exceptional among the ungulates of the same fauna in the number of crescents of the molars.

Char. specif.—Last molar with the oblique inner posterior crest terminating at the posterior margin of the crown. Prominent external ribs at the point of connection of the external crescents of the crown. No cingula; enamel entirely smooth.

Measurements.

	M.
Length (externally) of last four molars	.029
Length of true molars	.022
Length of penultimate	.009
Width of penultimate	.010

This animal was about the size of the raccoon, and probably had the habits of the tapirs.

BATHMODON SIMUS, *sp. nov.*

Represented by the remains of a great number of individuals, including all parts of the skeleton, dentition, &c., but especially by one of the most complete of these, which possesses, among other portions, the premaxillary bones. These indicate a species very distinct from the *B. radians*, Cope, and one approaching the *Metalophodon armatus* in the structure of the molar teeth.

The canine teeth have cylindric roots and trihedral crowns, the section of the latter forming a nearly equilateral spherical triangle. The crown of the inferior canines are shorter, and have one concave side. The superior molars support two crests, which are nearly parallel on the single and last tooth of this type. The posterior crest is composed of two portions, the posterior conic and the anterior flatter, and which becomes the external posterior crescent on the penultimate molar. The anterior cingular crest is very well developed on the last lower molar.

The premaxillary bone is short and stout, and descends steeply from an elevated front, presenting its three teeth downward. The canine follows closely from an elevated rib on the side of the face. Behind it is a considerable diastema. The humerus is a very stout bone, and the femur is rather slight in comparison with it.

Measurements.

	M.
Length of bases of last three molars	.083
Length of basis of last molar	.026
Width of basis of last molar	.035

	M.
Diameter of canine at base	.025
Length of penultimate inferior molar	.030
Width of penultimate inferior molar	.021

Individuals of larger size than the above are more common. Measurements of one of these are:

	M,
Length of last superior molar	.032
Width of last superior molar	.043
Diameter of crown of canine, (another species)	.030

This is the especially characteristic large mammal of this fauna, and must have existed in herds.

BATHMODON MOLESTUS, *sp. nov.*

Established on remains of one species and probably respresented by those of others in possession of the expedition. The teeth differ in several important respects from those of *B. radians* and *B. simus.* Thus the canine is quite compressed in the coronal portion, and is narrow triangular in section, the narrow base of the triangle being concave; that is, the section of a strong groove, which is bounded by a sharp edge on each side. The edge proper of the crown is also duplicated by a ridge of the enamel, which joins it at an acute angle. The last upper molar is characteristic in its wide crown, the posterior usually transverse crest being curved so as to represent the segment of a circle, the convexity posterior. The ramus of the lower jaw is very slender. The posterior inferior molar is large, and has subequal transverse crests. The posterior cingulum, which descends from the external angle, is moderately developed on both of the crests.

In a young specimen of this or an allied species of *Bathmodon*, the deciduous tooth which is replaced by the last premolar has two external crescents; an interesting point of resemblance to the *Perissodactyle* ungulates.

Measurements.

	M.
Width of anterior crest of last inferior molar	.023
Width of anterior crest of superior molar	.039
Length of superior molar	.029
Antero-posterior diameter of crown of canine	.022
Transverse diameter of crown of canine	.013
Depth of mandible at last lower molar	.050

BATHMODON LOMAS, *sp. nov.*

The very numerous remains of the genus *Bathmodon* obtained are referrible to several species, as indicated especially by the teeth. The present form is characterized among other points by the form of the last inferior molar. The anterior crest is much more elevated than the posterior, with its inner apex almost a cone, with anterior, thick, revolute border. The usual oblique cingulum descends from the outer apex forward. The longitudinal ridge connecting the crests is low but distinct, while the posterior cingular ridge is remarkably large. This, which constitutes one of the specific marks, is extended horizontally so as to form a broad ledge, whose border is a segment of a circle. Enamel roughened with five ridges on all the external surfaces. Tooth well worn by prolonged use.

Measurements.

	M.
Length of crown	.041
Width of crown anteriorly	.027
Width of posterior crest	.022
Elevation of posterior crest	.011
Elevation of anterior crest	.024

BATHMODON ELEPHANTOPUS, *sp. nov.*

The most abundant species of the New Mexican Eocene formation, and of the largest size, exceeding in this respect both the *B. simus* and *B. molestus.* I describe at present the last molars of both superior and inferior series. The former is a transverse oval, slightly swollen on the posterior border external to the middle point. The two crests are parallel, the anterior as usual curving round to the inner extremity of the shorter posterior, and leaving a wide interval between them. The posterior is not divided, but is elevated at the extremities. Anterior cingulum strong, posterior obsolete, excepting on the external border, where it sends a low ridge to the elevated extremity of the anterior crest. Exteroanterior to this ridge is a shallow fossa. Enamel very slightly rugose. The posterior lower molar exhibits a great disparity of elevation of the crests, the anterior being high, and terminating on the inner side in an elevated cone. The con-

necting ridge is low, and there is only a trace of a descending posterior cingulum on the posterior crest.

Measurements.

	M.
Width of last superior molar	.040
Length of last superior molar	.030
Length of last inferior molar	.039
Width of last inferior molar	.026
Elevation of posterior crest of inferior molar	.015
Elevation of anterior crest of inferior molar	.025

A remarkably fine skeleton of a species of this genus, discovered by my friend and assistant, William G. Shedd, exhibits characters heretofore only inferential, and demonstrates the correctness of a number of positions heretofore based on a few fragmentary bones. The feet exhibit proboscidian characters throughout. They are very short and plantigrade, and there are five digits on the hind foot. The calcaneum is recurved inward, and the astragalus flat above. The navicular is transverse and very thin, while the cuboid is subequilateral. The metatarsals are short, and the phalanges much wider than long. The cranium remarkably resembles that of a carnivorous animal in its massive expanded zygomas and huge canine tusks. It differs remarkably from this type, and shows its affinity to *Uintatherium* in the broad plane of the upper cranial wall, with overhanging marginal crests for the attachment and protection of the temporal and neck muscles. These crests do not support horns. The muzzle is contracted at the diastema, thus rendering more prominent the ridges which mark the position of the alveoli of the tusks. The latter are directed downward, giving the profile the pick-ax-like form of that of *Uintatherium*, though more robust in its proportions than the latter. The length of this skull is 19 inches; the width at the zygomas 13.

PHENACODUS PRIMÆVUS, Cope.*

Char. gen.—The genus *Phenacodus* was first recognized by the writer in a posterior inferior molar of a mammal of about the size of a hog, of unknown affinities, which was named *P. primævus*. Specimens of the same species, embracing the dentition of both jaws, having been procured in the Eocene of New Mexico, I am prepared to add to the characters of the genus.

There are three molars in each jaw, and the specimens include two premolars, which form a continuous series, as in *Achænodon*. There are four principal tubercles on the inferior molars and sometimes a third small one between the posterior pair, always on the last one, which is, however, not largely developed. The first inferior premolar presents a broad heel, a double medium tubercle, and an anterior tubercle, (in *P. primævus*.) The crowns of the superior molars are low and broad, and support numerous tubercles; these are low and vary in number, but there are two near the external border which are quite constant. They have general resemblances to those of hogs, bears, and monkeys. The first true molar is broader than long, and there are no diastemata between it and the premolars, or between the latter, which are quadri-, and tri-cuspid, respectively. The forms of these teeth are entirely different from those of the corresponding teeth in *Elotherium*.

Char. specif.—The posterior molar of the left side is wide in front and regularly oval in posterior outline, and has two equal anterior and three unequal posterior tubercles. One of the posteriors is situated near the middle of the outer side, and is separated from the adjacent anterior by a deep groove. The corresponding inner tubercle is more posterior; anterior tubercles low, trihedral, and connected by a shelf-like cingulum across the front of the tooth; rudimental cingula on outer side of crown. The penultimate molar has three tubercles on the posterior border; and a deep fissue, corresponding to that of the last molar, separates one of them from the anterior tubercle.

Measurements.

		M.
Length of last molar		.015
Width	anteriorly	.011
	between two posterior tubercles	.005
Elevation of anterior cusp from base		.008
Width of penultimate molar behind		.010

From the same locality as the preceding species.

PHENACODUS OMNIVORUS, *sp. nov.*

Superior molar with low and broad tubercular crown, with outline of base parallelogrammic, with one end oblique; the oblique end with two principal low tubercles,

* Paleontological Bulletin, No. 17, p. 3, October 25, 1873.

which form the extremities of two series of similar ones, some of which arise from the strong cingulum which forms part of the summit of the crown.

Char.—Molar without cingulum on the (?) outer side only; elsewhere very strong and crenate, at one point rising into a stout, low tubercle. The largest tubercle is near this, on the inner summit of the crown, and is connected with the larger outer by a low, broad tubercle. A smaller one intervenes between the cingular tubercle and the smaller external. The outer tubercles low and broad, a smaller one opposite the internal between them in the position of a cingulum. Enamel coarsely rugose.

Measurements.

	M.
Transverse diameter	.014
Longitudinal	.010
Distance between apices of inner and outer tubercles	.007
Elevation of cingulum	.004
Elevation of outer cusp	.005

The tooth described is about the size of the posterior inferior molar of the black bear, (*Ursus americanus.*)

PHENACODUS SULCATUS, *sp. nov.*

Represented especially by the molar tooth corresponding to that above described under the head of *P. omnivorus*, in good preservation. It is a species considerably less than half the size of the one just named, and presents several important differences of structure. Of the two outer tubercles, one is very small, and there is a third adjacent to the larger, produced by the enlargement of the cingulum. As in *P. omnivorus*, the cingulum extends entirely round the remainder of the crown, and is tubercular on the side of the least outer tubercle. The inner tubercle is connected with the larger outer by an intermediate of elongate form, so that the series when worn down resembles the transverse ridge of the superior molar of *Hyposyus*, and which is separated by a groove from the cingular ridge on each side.

Measurements.

	M.
Transverse diameter	.008
Longitudinal diameter	.006
Distance between apices of inner and outer tubercles	.004
Elevation of cingulum	.002
Elevation of outer cusp	.003

Size similar to that of the corresponding tooth of a *Coati.*

OXYÆNA LUPINA, *gen. et sp. nov.*

Represented by a portion of the cranium, which includes the greater part of the dentition. The generic characters are, three premolars and four molars above and below; lower premolars with anterior cone and posterior cutting heel; last premolar and all the molars of the superior series with an internal heel; the last molar transverse; first and second upper molars with an anterior cone and posterior cutting lobe; the penultimate with two anterior acute cones, the posterior forming a sectorial edge with the posterior lobe; last superior molar trenchant.

Mandibular dentition, I., 0; C., 1; P. M., 3; M., 3; the canine teeth directed forward and upward without intervening incisors. First premolar one-rooted; second and third consisting of an anterior elevated cone, and posterior heel, which is elevated in the middle.

The first true molar is nearly similar, with the posterior tubercle sharp edged. Last two molars with an anterior elevated portion and small low heel; the former consisting of three acute tubercles, of which the largest or interior forms with the anterior a sectorial blade oblique to the axis of the mandibular bone.

This genus has one less molar with double median cones than *Prototomus*. It is one of the flat-clawed group, of which two forms have already been described, *Mesonyx*, Cope, and *Synoplotherium*, Cope, which present in their dentition a nearer resemblance to the genus *Hyænodon* than to any other of later age. It differs from both the genera named in having only six molar teeth, and the triangular type of inferior sectorial teeth has not yet been obtained among them. The *O. forcipata* is the larger species; the smallest one described by me is the *Oxyæna morsitans*. In *Stypolophus brevicalcaratus*, I find three sectorials of the form described instead of two only.

Char. specif.—The posterior cutting lobes of molars 1 and 2 elevated and rather obtuse, that of molar 3 lower and more acute. Molar 2 has a well-marked anterior tubercle; molar 4 consists of an outer cutting edge and inner cone. The inner tubercle of molar 3

is smaller than in the three teeth preceding. First lower premolar well developed with one root. Enamel of all the teeth, especially of the canines, rugose.

This species is allied to those of the genus *Pterodon.*

Measurements.

	M.
Length of four posterior superior molars	.055
Length of first true molar	.016
Width of first true molar	.015
Length of second true molar	.016
Width of third (transverse) molar	
Length of five anterior inferior molars	.054

This species is intermediate in size between the *O. forcipata* and *O. morsitans.* The penultimate inferior molar differs from that of both these species in the much weaker development of the internal lateral tubercle and more obtuse anterior tubercle; in *O. forcipata* the blade is continued on the front of this tubercle.

Two specimens embracing five series of teeth have been examined by the writer; the measurements given are those of the smaller.

OXYÆNA MORSITANS, *sp. nov.*

The genus of flesh-eating mammals, described in 1872 under the name of *Stypolophus,* presents a type of dentition which is further illustrated by the present addition of new species much larger than any hitherto known to possess it. Those described are in the order of size: *S. insectivorus, S. pungens,* and *S. brevicalcaratus,* Cope. The present new species is twice the bulk of the last. It is represented by broken mandibles with molars and canines of two specimens, and part of the maxillary dentition of a third. The molar, which is typical of the genus, in its subtriangular basis supporting three elevated cusps, and a short heel, is evidently functionally the sectorial, whatever its homological relations may be. In the present instance, the inner posterior cusp is much reduced, while there is a small additional cusp on the front of the anterior near its basis. The trihedral outer posterior forms a cutting edge with the large outer anterior, which is produced forward. A posterior molar exhibits a corresponding tricuspidate portion, and a more elongate heel, with acute circumference. In a premolar, the posterior heel becomes trenchant and median. The canine is very stout and compressed at basis. The enamel in all the teeth is more or less rugose.

Measurements.

	M.
Length of base of crown of sectorial tooth	.014
Width of base of crown of sectorial tooth	.009
Elevation of principal cusps	.015
Elevation of inner posterior cusps	.007
Length of basis of posterior molar	.012
Width of basis of posterior molar	.007
Length of heel of posterior molar	.005
Elevation of principal cusps	.011
Elevation of anterior cusps	.006
Long diameter of canine at base	.018

The maxillary series belongs to a still larger animal. The sectorial presents the same form as that of the mandibular series, and is more robust in form than in existing *Carnivora.* The section of the middle crests is very convex on the inner side, so that the shear is oblique. The heel is small and low. The premolar preceding has a large, broad heel. In another premolar, the heel supports a median crest, while the anterior part of the crown is a slightly-compressed cone, with a small tubercle at the anterior base. Other specimens indicate that this species lacks the inferior incisor teeth.

OXYÆNA FORCIPATA, *sp. nov.*

Char. specif.—Mandibular rami robust and deep, with the symphysis short, and the chin contracted. The canine tooth forms a vertical oval in section. The first one-rooted premolar is a stout tooth; there is no anterior basal tubercle on the second and third premolars, but a distinct one on the first true molar. There is a small tubercle at the base of the anterior lobe of the last or second sectorial molar. This tooth is larger than the penultimate. The enamel of all the teeth is quite rugose, although they are well worn by use.

Corresponding characters are exhibited by four specimens of this species, one of which includes portions of the upper jaw. All the bones are particularly massive, and there is a high parietal crest, a fair indication of the size of the temporal muscles.

Additional specimens of the *Oxyæna morsitans,* Cope, show that it differs in the reduced size of the sectorial molars, and the very small first premolar, which is quite rudimental.

Measurements.

	M.
Length of inferior dental series	.103
Depth of ramus at last molar	.040
Depth of ramus at second premolar	.030
Diameter of canine tooth	.019
Length of premolar series	.035
Length of base of penultimate molar	.016
Length of base of last molar	.019
Width of base of last molar	.012
Elevation of crown of last molar	.019
Length of superior last molar	.020
Width of superior last molar	.013

This animal differs in specific characters from the Wyoming carnivores, already referred to, in the greater robustness of all its parts. From *Synoplotherium lanius*, it also differs in the regular increase backward in the size of the molars. In the Wyoming species the penultimate is largest in the lower jaw.

The fragments of the *Oxyæna forcipata* are as large as corresponding parts of the jaguar.

PACHYÆNA OSSIFRAGA, *gen. et sp. nov.*

Char. gen.—Established on a single superior molar tooth of a large carnivore, apparently allied to the group of flat-clawed *Carnivora*. It is either the last premolar or first true molar. It is characterized by the absence of the cutting edge seen in the allied genera, and its replacement by a conic tubercle.

The principal lobe is also a cone, and the inner one a perfect cone, a little less elevated than the principal one.

Char. specif.—Crown with well-developed anterior and posterior basal tubercles; no cinguli, either internal or external. Enamel slightly rugose.

Measurements.

	M.
Length of crown	.020
Width of crown	.018
Elevation of anterior basal tubercle	.006
Elevation of central cone	.011
Elevation of interior cone	.010

This is the largest carnivore yet observed in this formation, and of peculiar character; its structure indicating a diet not purely carnivorous.

PROTOTOMUS VIVERRINUS, *gen. et sp. nov.*

Char. gen.—Three true molars in the maxillary bone; premolars compressed, the last of the upper series triangular in form; each angle enlarged; the center of the crown with a compressed conic tubercle. First and second true molars triangular, with a tubercle at each angle, and two adjacent cones in the center. The tubercle of the posterior angle forms a slight sectional edge with the posterior of the central pair. Last (third molar) transverse, with a median cone. Supposed mandible with the posterior two molars tubercular; the anterior tubercles similar to the posterior.

This genus is evidently allied to the *Viverridæ*, differing from *Viverra*, so far as known, in the simple character of the last two inferior molars. From *Limnocyon* it differs, according to Professor Marsh's descriptions, in possessing three instead of two superior true molars, or, if we include with these the last premolar, as does Professor Marsh, four instead of three. According to Professor Marsh, the tubercular molars in his *Vulpavus* are generally similar to those of the existing genus *Canis*. *Prototomus* presents the number of superior molars seen in *Amphicyon*.

Char. specif.—The *P. viverrinus* is established on a considerable part of the cranium and skeleton of one individual in good preservation. The last upper premolar is triradiate, having concave and subequal sides. The first molar is as broad as long, and is triangular, presenting a right angle outward and forward.

The second molar is broader than long, and presents an acute tubercle on the anterior border between the inner and anterior median cones. There is a tubercle at the inner and outer extremities of the base of the last molar. No cingulum on the posterior or outer sides of the last premolar. External cones of the last two inferior molars subcrescentic in section; anterior inner obsolete; posterior inner prominent.

Measurements.

	M.
Length of last five molars	.0250
Length of true-molar series	.0135
Length of last premolar	.0060
Width of last premolar	.0050
Length of penultimate molar	.0050
Width of penultimate molar	.0068
Width of last molar	.0047
Length of last two inferior molars	.0090

About the size of the domestic cat.

PROTOTOMUS INSIDIOSUS, *sp. nov.*

Represented in the collections of the survey by parts of the maxillary bone and both mandibular rami with teeth. The species is much less than the preceding, and differs materially in the forms of the teeth. The two anterior tubercles of the tubercular molars are similar and approximated; the posterior slightly divergent, and on the last tooth inclosing a third of small size. The last premolar has a broad heel and stout anterior cone, but no anterior tubercle. The tooth immediately preceding is much smaller, and also possesses a heel. The mandibular ramus is particularly slender, and the angle is not inflected.

Measurements.

	M.
Length of last two inferior molars	.0060
Length of last molar	.0034
Width of last inferior molar	.0020
Depth of ramus at last inferior molar	.0045
Length of last premolar	.0030
Elevation of last premolar	.0028

PROTOTOMUS JARROVII, *sp. nov.*

This *Carnivore* is of considerably larger proportions than either of the preceding. It is readily recognized as pertaining to the same genus by the identical form of the last two inferior molars, which are quite different from the corresponding ones in *Oxyæna* and other genera. These indeed, with the portion of the mandibular ramus which supports them, are the only well-preserved remains of this animal as yet in our possession. They indicate an animal of the size of the gray fox. In the last molar, the inner anterior tubercle is double, though low and obtuse. It differs from that in the species last enumerated in the presence of only two tubercles on the posterior portion of the crown instead of three, one being terminal and the other on the middle of the outer side. There are but two on the posterior end of the penultimate tooth, and all are low and unconnected excepting by the distinct rim of the crown. The center of the crown is thus concave. The rim is interrupted by notches between the tubercles on the outer side. No cingulum on inner, a weak one on outer side. Enamel smooth.

The form of the molars is rather stout, and the ramus is thick and not deep, and with broad, simple, lower border below the molars.

Measurements.

	M.
Length of last lower molar	.0070
Width { anteriorly	.0045
Width { posteriorly	.0020
Width of penultimate behind	.0050
Elevation of anterior cusp of last	.0030
Depth of ramus at last molar	.0140

This species is dedicated to my friend Henry C. Yarrow, M. D., to whom was committed the charge of that party of the survey to which I was attached, and to whose zeal in the cause of the natural sciences the success of the special expedition is largely due.

LIMNOCYON PROTENUS, *sp. nov.*

A civet-like Carnivore represented by one entire and a portion of the other mandibular ramus, with teeth well preserved, agrees in generic characters with the species referred by Professor Marsh to his genus *Limnocyon*, but differs from them all in its superior size. The molars are $\frac{?}{3}$, but the first molar is like the premolars of the *Canidæ*, except in a slight widening of its posterior basis by the development of a broad cingulum on the inner side and round the basal lobe behind. From this point it extends forward on the outer side to the beginning of the anterior basal lobe, and there

ceases. The second molar has the anterior portion elevated, supporting three cusps and a large heel, with lateral and sub-median cutting edges. The last molar is smaller, elongate, oval, and two-rooted, with marginal posterior, intermarginal external, and two anterior tubercles, of which the inner is bifid. The ramus is slender, and the symphysis elongate. The angle is not incurved. First premolars one-rooted.

Measurements.

	M.
Length of dental series	.0680
Length of four premolars	.0340
Length of first molar	.0105
Length of second molar	.0100
Width of second molar	.0055
Length of third molar	.0080
Width of third molar in front	.0040
Depth of ramus at third premolar	.0130
Depth of ramus at last molar	.0150

ALLIGATOR CHAMENSIS, *sp. nov.*

Represented by portions of the mandibular arch of a small crocodilian resembling in some respects the *A. heterodon* of the Wyoming beds. The posterior teeth have the same short, expanded, sessile, bean-shaped crowns, with a median longitudinal ridge, and more delicate lines radiating close together from it to the border of the crown. The anterior teeth differ in being cylindric instead of compressed. There is a large canine preceded and followed by teeth of much smaller size.

Measurements.

	M.
Length of symphysis	.019
Length of alveoli of six teeth from symphysis	.022
Width of ramus just behind symphysis	.010
Long diameter of posterior tooth	.005

The specimens selected as type is one of the smallest. The surface of the bones is roughened with pits.

PLASTOMENUS LACHRYMALIS, *sp. nov.*

The largest species of the genus, and abundantly represented in the Eocene of New Mexico. The costal bones are rather finely punctate, the posterior as well as the anterior. The anterior costal bones are crossed by numerous ridges from side to side obliquely; the obliquity increasing posteriorly. On the posterior bones, they are broken into vertical bars, separated by considerable intervals, and of linear form. The posterior costals reach a thickness of $0^{m}.006$ and a width of $0^{m}.025$.

The pitting of the posterior part of the carapace distinguishes this species from the *P. œdemius*.

PART II.

In addition to the investigations pursued in the regions already indicated, and of which some of the new species have been described, it may be stated that a careful examination was made of the extensive lacustrine deposits in the valley of the Rio Grande.

These deposits are supposed to commence to the northward of Taos, N. Mex., and continue to an unknown distance southward, certainly at least fifty miles beyond Santa Fé, and occupy that portion of the valley between the Rocky Mountains in the east and the Jemez range in the west, and have been stated as late Tertiary, but without special determination or co-ordination with the other known lacustrine formations of this continent.*

Abundant material having been obtained by the party, it is easy to determine the fauna, whose remains are entombed in it, to be a part of that already described by Dr. Leidy and the writer as occurring in Dakota and Colorado under the name of Pliocene. This conclusion is indicated by the presence of the genera *Hippotherium*, *Protohippus*, *Procamelus*, *Cosoryx*, and *Merychippus*, and known Pliocene species of other genera, among which may be mentioned *Canis*, *Aceratherium*, &c. In addition to species already known, a number new to science were obtained, of some of which descriptions are here given.

MARTES NAMBIANUS, *sp. nov.*

Represented by a mandibular ramus, which supports three teeth. The anterior blade of the sectorial is rather obtuse.

* The new species described from the valley of the Rio Grande were discovered from August 20 to September 1, 1874.

The first premolar is one-rooted; the second and third are without posterior coronal lobes, but exhibit small basal lobes, both anterior and posterior. The anterior of the second is rather elevated, and the entire crown is directed obliquely forward. Canine compressed; mental foramina below the second and third premolars.

Measurements.

	M.
Length of three premolars	.006
Elevation of anterior lobe of sectorial	.002
Depth of ramus at anterior lobe of sectorial	.003

This species is of smaller size than the *M. mustelinus*, Cope, and the sectorial tooth less elevated and trenchant.

COSORYX RAMOSUS, *sp. nov.*

Char. gen.—Inferior molars prismatic, $\frac{3}{3}$; the premolars all sectorial, last with short branch-crests. Molars with basal intercolumnar tubercles. Horns superciliary, solid, branched. This genus was indicated by Dr. Leidy from a horn of the species known to him, the *Cosoryx furcatus*, from the Pliocene beds of the Niobrara. The same or a similar species has left abundant remains in the Santa Fé marls, and, in connection with the more numerous *C. ramosus*, has enabled me to determine the dental and other characters of the genus. After a careful examination of the horns of these species in my possession, those of eighteen individuals (at least I find that of ten where the basal portion is preserved) the beam has been broken off and reunited by anchylosis in six. In most of these the spot is marked by a ring of exostosed tuberosities, like those constituting the burr of the deer's horn. On a specimen of this character, pertaining to a third species, Professor Leidy based his *Cervus warrenii*, which may now be called *Cosoryx warrenii*. It is abundant in the Santa Fé marls.

The fracture has taken place in every instance at a point as far above the frontal bone as the burr of deer is situated, and is irregular in outline, higher on the one side than the other. In some of the specimens the smaller antlers are also broken, and exhibit a similar burr, but the terminal portion is usually lost. In one specimen, a broken antler is anchylosed in the usual manner of overlapping ends. The horns are solid, the center having a narrow, spongy axis. The surface is dense and marked by arterial grooves, but not pierced by noticeable foramina.

It is evidently a question whether this genus should be referred to the hollow or solid-horned *Ruminantia;* to the *Bovidæ*, or *Cervidæ*. The horns might be regarded as those of deer were it not for the occasional specimens without burr, while the teeth are both cervine and bovine. We may here draw such inferences as we can respecting the nature of the covering of the horn. That the fractured beam should not be lost indicates the presence of some kind of covering to retain it. That this covering was not horny is probable from the fact that the horns are branched, a structure impossible to the *Bovidæ*, since antlers effectually prevent the usual mode of increase of horn by additions at the base and removal at the extremity. That such covering protected arteries, which aided in the production of burrs, is also probable. We may thus believe it to have been dermal like that of the giraffe, or the *Antilocapra*, at the period of immaturity of its horny sheath.

It may be concluded, then, that the genus *Cosoryx* represents the ancestral type of the *Cervidæ*, and explains the origin of the remarkable type of horns of that family as follows: Ruminants with fixed horns of structure more dense and brittle than others of the same type, in their annual combats at the rutting-season, very frequently broke the beams off not far above the base. The usual location of nutrition followed, which, being annually repeated, became as periodical in its return as the activity of nutrition of the reproductive system. This activity ceasing, the horn, being dense, lost its vitality, the more so as the normal covering would have already perished in its distal portions. The natural consequence, the separation of the dead from the living bone by suppuration, would follow. This process would, however, probably require a longer time for the establishment of its periodical return than the fracture and attachment of the existing horn.

This appears to be the only explanation of the origin of the phenomena exhibited by the horns of the *Cervidæ*, and is suggested by the specimens of *Cosoryx* to be described.

Char. specif.—This species is larger than the *C. furcatus*, Leidy, and differs from the *C. warrenii* in possessing two antlers instead of one, of which the first is given off at a point much farther from the base than in that species.

The beam near the base is curved a little inward, and is semicircular in section, the outer face being slightly concave, the inner very convex. The base is situated a short distance within the free superciliary border. The beam becomes more cylindric, and then, expanding in a fore and aft direction, gives off an antler at right angles nearly parallel to the cranial axis. At a distance little over half the elevation of the first antler, the beam gives off a second in a plane tranverse to the axis of the skull. The terminal portion of the beam is cylindric, curved, and acute at the apex.

Mandibles, with teeth of two species of this genus, were found, the smaller of which occurring with the other portions of *C. furcatus*, belong to it. The larger differs in the elevation of the intercrescentic column of the first molar, which is worn into a loop at ordinary maturity; this may, however, be but an individual variation. The diastema is long and the ramus of that point quite slender.

Measurements.

	M.
Long diameter of base, No. 1	.016
Long diameter of base, No. 2	.020
Elevation of first antler from base, No. 1	.080
Elevation of second antler from first, No. 3	.042
Length of terminal part of beam, No. 4	.095
Length of molars 2–5, No. 5	.037
Length of molars 4–5, No. 5	.022
Length of fifth molar	.012
Width of fifth molar	006

COSORYX TERES, *sp. nov.*

Established on the connected frontal bones, supporting the horns of one specimen, and represented by portions of horns of two others. The former individual is larger than any one belonging to the other species, and the species is doubtless the largest of the genus. The horns stand above the posterior part of the orbit, which excavates its base, and presenting a considerable face, descending into the temporal or zygomatic fossa. There is no free superciliary rim outside of the base as in *C. ramosus*, Cope. The section of the beam near the base is a regular oval; the long axis directed longitudinally and a little outward in front. The beam is erect, with a slight curvature outward at the inner base only. So far as preserved, it does not branch, but may do so in its distal portion, which is lost. The tissue is more spongy interiorly than in the other species; supraorbital foramen far within the superciliary border.

Measurements.

	M.
Outer width between bases of horn-cores	.112
Inner width between bases of horn-cores	.055
Width of temporal fossa behind horns	.053
Long diameter of horn-core	.028
Short diameter of horn-core	.021
Length of part preserved	.033

This species was as large as the *Antilocapra americana* of the plains.

HESPEROMYS LOXODON, *sp. nov.*

An entire mandibular ramus, with all the teeth preserved, was found in the same deposits as the preceding species. Molars subequal, short-crowned; triturating surface sigmoid. The apices of the sigma on the inner side tubercular, and anterior to the outer apices. First molar with an additional transverse crest in front. Incisor compressed; outer angle of enamel face rounded smooth. Molar series oblique, rising anteriorly.

Measurements.

	M.
Length of molar series	.0050
Length of first molar	.0018
Depth below last molar, (inner side)	.0030
Depth below first molar	.0045
Depth of incisor	.0015
Depth at diastema	.0027

PANOLAX SANCTÆFIDEI, *gen. et sp. nov.*

Char. gen.—Molars prismatic, transverse, except the first and last; each divided by a plate of enamel extending transversely from the inner side. Anterior molar longitudinal; posterior molar composed of two columns.

This genus is represented by numerous teeth and portions of the cranium. It evidently belonged to the *Leporidæ*, and is allowed to both *Lepus* and *Palæolagus*. As the teeth are mostly separate, it is not easy to determine which is the posterior and which the anterior molar. Judging by the analogy of the known species, the determination as here made is correct; should the relations be reversed, the species will be referred to *Palæolagus*.

Char. specif.—The teeth are curved, the convexity inward. Inner face grooved, the groove occupied by cementum, the outer border compressed either without or with

very shallow groove. First molar with triturating surface twice as long as wide, w an entering loop of enamel on the inner side anteriorly narrower. Last molar as w antero-posteriorly as transversely, the shaft curved backward, the posterior colu sub-cylindric half the diameter of the anterior.

Measurements.

		I
Diameter of middle molar	antero-posterior	[illegible]
	transverse	[illegible]
Diameter of first molar	antero-posterior	[illegible]
	transverse	[illegible]
Diameter of last molar	antero-posterior	[illegible]
	transverse	[illegible]
Length of crown of last molar		[illegible]

This species is about the size of the northern hare.

CATHARTES UMBROSUS, *sp. nov.*

Represented by numerous portions of nearly all parts of the skeleton, in excelle preservation. The beak from the frontal bone to near the apex is preserved; it di plays the depression just anterior to the nares, which marks the anterior boundary the cere. The culmen is nearly horizontal to just beyond this mark, and then exhibi a gradual decurvature to the apex. The beak is strongly compressed, and the tom strongly decurved, forming an open festoon, whose middle point marks one-fourth tl length of the beak from the nares. The latter are directed obliquely downward an forward, narrowing anteriorly and having a prominent inferior bounding ledge.

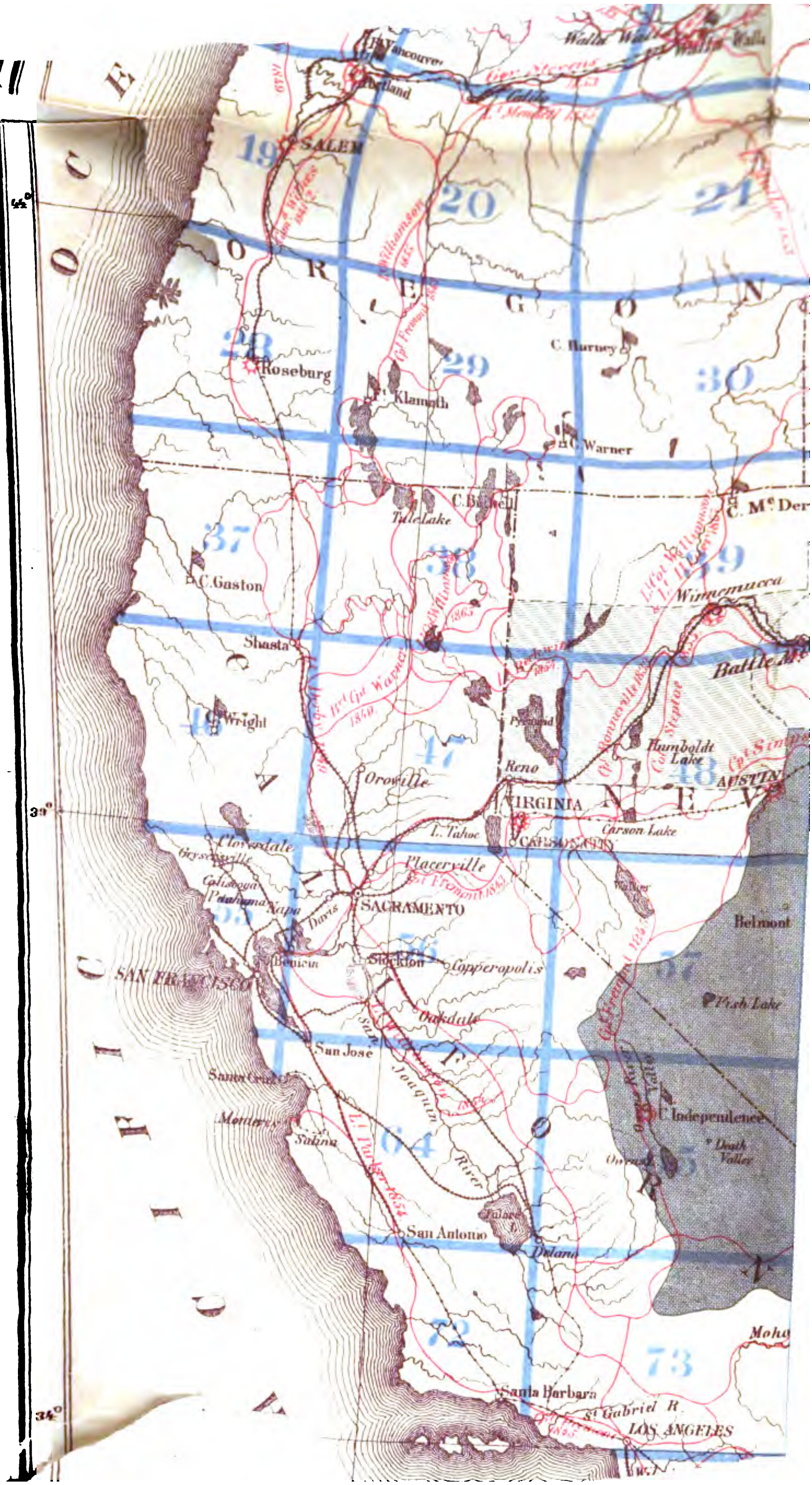
The mandible is weak, the symphisis-marking on half the length of the beak fro the anterior angle of the nares.

The bones of the anterior extremities exhibit large and powerful proportions, a compared with the posterior, appropriately to capacity for sustained flight. The hea of the humerus is much compressed, and the articular face is nearly divided into tw by the deep bicipital groove. The head of the femur is small, and the rotular face wide and deep groove.

The tibia is slender, the shaft much compressed, with a prominent ridge. Th cnemial crest is short, and not produced downward on the shaft. The distal posterio bridge is narrow and oblique. The tarso-metatarsus has a strong exterior crest, whic constitutes half the width of the shaft.

Measurements.

	Inch
Length of beak from base of culmen, (axial)	1.9
Length of beak from cere to apex, (axial)	1.2
Depth of beak at culmen	.87
Depth of premaxillary at festoon	.7
Length of symphysis	.6
Length of nares	.37
Width of palate at festoon	.50
Width of head of humerus	1.37
Width of condyles	1.13
Width of distal end of femur	.94
Width of head of tibia	.81
Width of condyles of tibia	.66
Width of condyles of tarso-metatarsus	.75
Length of a first phalanx	1.12
Length of seven sacral vertebræ	1.87
Length of two dorsal vertebræ	1.12
Depth of a dorsal vertebra, (total)	.93
Depth of a dorsal vertebra to roof of arch	.44
Depth of centrum of roof of arch	.25
Width of centrum of roof of arch	.32
Length of two cervical vertebræ	1.12
Depth of two cervical vertebræ to apex of neural spine	.44
Depth of articular face of centrum	.17
Width of articular face of centrum	.25


OCEAN
PACIFIC
OREGON
CALIFORNIA
NEVADA
Vancouver
Portland
Walla Walla
Dalles
SALEM
Roseburg
Ft. Klamath
C. Harney
C. Warner
C. Bidwell
Tule Lake
C. McDermit
C. Gaston
Winnemucca
Shasta
Battle Mt.
C. Wright
Pyramid
Humboldt Lake
AUSTIN
Oroville
Reno
VIRGINIA
CARSON CITY
L. Tahoe
Carson Lake
Walker
Cloverdale
Geyserville
Calistoga
Petaluma
Napa
Davis
SACRAMENTO
Placerville
Belmont
Benicia
Stockton
Copperopolis
SAN FRANCISCO
Oakdale
Fish Lake
San José
San Joaquin
Santa Cruz
C. Independence
Monterey
Salinas
Death Valley
River
San Antonio
Tulare L.
Delano
Santa Barbara
St. Gabriel R.
LOS ANGELES
Mohave
44°
39°
34°
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57
64
72
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nch.
.093
187
.140
.062
100
065
250

nt

ANNUAL REPORT

UPON THE

U.S

GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN, IN CALIFORNIA, NEVADA, NEBRASKA, UTAH, ARIZONA, COLORADO, NEW MEXICO, WYOMING, AND MONTANA,

BY

GEORGE M. WHEELER,

FIRST LIEUTENANT OF ENGINEERS, U. S. A.;

BEING

APPENDIX L L

OF THE

ANNUAL REPORT OF THE CHIEF OF ENGINEERS FOR 1875.

[EXTRACT FROM THE ANNUAL REPORT OF THE CHIEF OF ENGINEERS TO THE SECRETARY OF WAR.]

OFFICE OF THE CHIEF OF ENGINEERS,
Washington, D. C., October 18, 1875.

* * * * * * * *

GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN.

Officer in charge, First Lieut. George M. Wheeler, Corps of Engineers, having under his orders First Lieuts. William L. Marshall, Philip M. Price, and Eric Bergland, Corps of Engineers; First Lieut. William L. Carpenter, Ninth United States Infantry; First Lieut. Rogers Birnie, jr., Thirteenth United States Infantry; First Lieut. S. E. Blunt, Ordnance Corps; Lieut. C. W. Whipple, Third United States Artillery, and Lieut. C. C. Morrison, Sixth United States Cavalry; Acting Asst. Surgs. H. C. Yarrow and J. T. Rothrock, United States Army, who, in addition to their professional duties, were engaged in zoological and botanical labors.

The following scientists have also been attached to the expedition: Dr. F. Kampf and Mr. John H. Clarke, astronomical observers; Messrs. G. K. Gilbert, A. R. Conkling, Jules Marcou, and Douglas A. Joy, geologists; Prof. E. D. Cope and Dr. C. A. White, paleontologists; and Dr. Oscar Loew, mineralogist and chemist.

At the commencement of the fiscal year the main divisions of the survey were about leaving their rendezvous at Pueblo, Colo., for the field of operations in Southern and Southwestern Colorado, Northern and Northwestern New Mexico, and Northeastern Arizona, where connection was made with work of former years in areas represented by portions of atlas sheets 61, 62, 68, 69, 70, 76, and 77. (See progress-map.)

Several primary astronomical stations both near to and remote from the field of survey were determined, in addition to the usual field astronomical observations.

The several parties were disbanded at Pueblo at the close of the field-season in November and December, following which the requisite number of assistants repaired to Washington for the preparation, during the winter months, of results, and where a small force of draughtsmen and computers is constantly employed in the reduction of field-notes.

The field-work of the present season was divided into two sections, the Colorado and the California, and was begun early in June.

A special party intrusted to the charge of Lieutenant Bergland will make a preliminary instrumental survey, with a view to the further and more complete examination of the feasibility of diverting the waters of the Colorado River of the West for purposes of irrigation, and it is hoped that a report and accompanying estimates will be received from the officer in charge of the party in time to be submitted to you early in the coming winter.

Of the six quarto volumes authorized to be published by the act of June 23, 1874, as amended by the act approved February 15, 1875, two

are in the hands of the printer, the manuscript of two others is nearly ready, and that of the remaining volumes is in an advanced stage of preparation.

Four published sheets have been added to the topographical atlas, and others are completed and in course of construction.

Proof-sheets of four of the maps of the geological atlas have been received, and four more sheets are ready for the engraver.

So far as compatible with the main objects of the survey, to wit, the preparation of detailed topographical maps and an examination into the resources of the region surveyed, scientists, selected for their fitness to conduct investigations in geology, paleontology, mineralogy, zoology, and botany, are attached to the expeditions, with little increase in cost as compared with the information gained in these subjects.

The topographical maps, which form the chief results of this survey, furnish important information to the different branches of the military service, and other departments of the Government, and to the public. Its regular progress without interruption is earnestly recommended.

The amounts required to continue the survey are estimated by Lieutenant Wheeler as follows:

For continuing the geographical explorations and surveys of the territory of the United States west of the 100th meridian	$95,000
For preparing, engraving, and printing the plates and atlas-sheets accompanying the reports of the geographical explorations and surveys west of the 100th meridian	25,000

His annual report, with appendixes and estimates, is appended.

(See Appendix LL.)

* * * * * * * *

ERRATA, APPENDIX L L.

Plate II. One-half natural size.
Plate V. One-third natural size.
Plate VI. One-third natural size.
Page 5, 27th line, for astronominal, read astronomical.
Page 8, 22d line, for establised, read established.
Page 29, 21st line, for Chaco Valley, read Chaco River.
Page 40, 10th line, for Tetella Peak, read Tetilla Peak.
Page 42, 33d line, for Naciuniento, read Nacimiento.
Page 42, 35th line, for Cannonus Creek, read Cañones Creek.
Page 42, 63d line, for Vermajo Creek, read Vermejo Creek.
Page 42, 6th line, for Cuemo, read Cuerno.
Page 42, 23d line, for Larzo, read Largo.
Page 42, 24th line, for Cenesal, read Cerezal.
Page 42, 35th line, for Punco, read Puerco.
Page 42, 35th line, for Abiquin, read Abiquiu.
Page 42, 49th line, for Ojo Salado, read Ojo Zarco.
Page 42, 49th line, for Chemisal, read Chamisal.
Page 42, 56th line, for Moreus, read Moreno.
Page 42, 56th line, for Cienaquilla, read Cineguilla.
Page 43, 18th line, for Ryado, read Rayado.
Page 43, 18th line, for Urac, read Uraca.
Page 43, 4th line, for Vaco, read Vaca.
Page 43, 35th line, for Ratton, read Raton.
Page 43, 54th line, for Elk Lake, read Black Lake.
Page 43, 61st line, for Bemal, read Bernal.
Page 44, 17th line, for Manco Buno, read Manco Burro.
Page 44, 22d line, for Apispah, read Apishpah.
Page 45, 64th line, for La Late, read Lata.
Page 45, 6th line, for Ceno Blanco, read Cerro Blanco.
Page 45, 63d line, for Manco, read Mancos.
Page 46, 47th line, for Tuncheras River, read Trinchera Creek.
Page 53, 25th line, for "worth of compensation," read "want of," &c.
Page 53, 45th line, for "was referred," read "is referred," &c.
Page 53, 46th line, for "a differential value," read "differential values," &c.
Page 61, 2d paragraph, last line, for west and south, read east and south.
Page 62, 14th line, for Shyenne mts., read Shyenne Mt.
Page 64, 4th line, for proposed, read supposed.
Page 68, 2d paragraph, for Amphicyous, read Amphicyons.
Page 68, 10th line from bottom, for ramii, read ramus.
Page 69, 8th line, for Merycodis, read Merycodus.
Page 69, 20th line, for Merycodon, read Merycodus.
Page 69, 28th line, for Dicroceerus, read Dicrocerus.
Page 70, 23d line, for Pajuaque, read Pojoaque.
Page 70, 11th line from bottom, for lunæ, read lunar.
Page 70, 4th line from bottom, for oval, read oral.
Page 71, 3d line from bottom, for acedatherium, read aceratherium.
Page 73, 18th line, for "at base tusks," read "at base of tusks."
Page 73, 21st line, insert semi-colon after "only" and, "is defined" after "the other."
Page 74, 14th line, for Lestudo, read Testudo.
Page 74, 27th line, for Testudas, read Testudos.
Page 74, 31st line, for I. Niobrarensis, read S. Niobrarensis.
Page 75, 38th line, for common, read cannon.
Page 75, 7th line from bottom, for auchitherium, read anchetherium.
Page 76, 21st line, for Chamra, read Chama.
Page 76, 25th line, for Playa, read Plaza.
Page 76, 25th line, for Chalma, read Chama.
Page 76, 26th line, for nambe, read Nambé.
Page 76, 31st line, for artemesia, read artemisia.
Page 77, 5th line, for Zandia clay, read placita marl.
Page 80, 24th line, for east, read west.
Page 80, 4th line from bottom, omit "*so as*" and "continue."
Page 81, 4th line, insert "southward" between "descend" and "to."
Page 87, for Pig. 11, read Fig. 11, and for Vegas, read Yeguas.

ERRATA—Continued.

Page 88, 12th line from bottom, for Vegas, read Yeguas.
Page 88, 16th line, insert "results" after word "hog-backs."
Page 88, 9th line from bottom, for "composed of," read "composed at."
Page 89, 35th line, for Vegas, read Yeguas.
Page 89, 1st line, second paragraph, Vegas, for Yeguas.
Page 92, 1st line, fourth paragraph, for Green River, read Wahsatch.
Page 92, last line, for western, read eastern.
Page 93, 28th line, for stagnolis, read stagnalis.
Page 93, 20th line from bottom, for 10th Meridian, read 100th Meridian.
Page 93, 15th line from the bottom, for Sarcolemon, read Sarcolemur.
Page 95, under "crocodilia," for spenops, read sphenops.
Page 104, 25th line from bottom, for base and slate, &c., read base; and slate, &c.
Page 105, 25th line, for proxide, read peroxide.
Page 105, 26th line, for perotoxide, read peroxide.
Page 107, 14th line, for sky, blue, read sky blue, &c.
Page 112, 4th line from bottom, for apposition, read opposition.
Page 117, 25th line, fourth paragraph, for Sanoita, read Sonoita.
Page 119, 2d line, for acantho carpa, read acantho-carpa.
Page 121, 50th line, for helenium, read Helenium.
Page 122, 33d line from bottom, for de la Golondima, read de la Golondrina.
Page 122, 18th line from bottom, for Nezundol, read Negundol.
Page 122, 7th line from bottom, for Agare, read Agave.
Page 122, 5th line from bottom, for Cereus gigantus, read C. giganteus.
Page 124, 12th line from bottom, for Machoeranthera, read Machebranthera.
Page 124, 11th line from bottom, for Veneris asplenerom, read Veneris and asplenium.
Page 125, 5th line, for agave, read Agave.
Page 125, 23d line from bottom, for goniphrena, read goniphrena.
Page 126, 8th paragraph, first line, for portulaca, read Portulaca.
Page 126, 8th paragraph, first line, for chenopodium, read Chenopodium.
Page 129, 3d line from bottom, for Cerro Blanco, read Sierra Blanca.
Page 133, 3d paragraph, 9th line, for Rio Turreones, read Rio Torreones.
Page 134, 9th line from bottom, for Rio Silla, read La Silla.
Page 135, 12th line from bottom, for in barrows, read by burros.
Page 137, 21st line from bottom, for albuminate fats, read albuminate, fats.
Page 139, 17th line from bottom, for arnudo, read arundo.
Page 144, 27th line from bottom, for Helo derma, read Heloderma.
Page 148, 14th line, for spendens, read splendens.
Page 150, 25th line from bottom, for frosts, read forests.
Page 151, 9th and 10th lines from bottom, for arctic, read long-spurred.
Page 153, 28th line, for hutchingsii, read hutchinsii.
Page 157, 22d line from bottom, for Myiodestes, read Myiadestes.
Page 158, 17th line from bottom, for western ridgways, read Ridgways.
Page 159, 7th line, for Mequite, read Mesquite.
Page 163, 5th line, for Syrnum, read Syrnium.
Page 164, 5th line, for Cass, read Coues.
Page 165, 22d line, for Foot, read Fort.
Page 170, 16th line from bottom, for of this number, &c., are, read of these, number, &c., is.
Page 171, 4th line from bottom, for Vegas, read Yeguas.
Page 175, 2d line, for Kan-ayko, read Kanayko.
Page 175, 9th line, for Tiguet, read Tiguex.
Page 177, 22d line from bottom, for Castenade, read Casteñada.
Page 178, 2d line, for Huatl-vi, read Hualvi.
Page 178, 8th line, for Kan-Ayko, read Kanayko.
Page 184, 21st line from bottom, for moen read moon.

REPORT.

APPENDIX LL.

ANNUAL REPORT OF LIEUTENANT GEORGE M. WHEELER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1875.

GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN, IN CALIFORNIA, NEVADA, NEBRASKA, UTAH, ARIZONA, COLORADO, NEW MEXICO, WYOMING, AND MONTANA.

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Plate III.—View taken from the western flank of the Gallinas Mountains, looking north.
Plate IV.—View from ruin No. 1 of Cristona, looking south.
Plate V.—*Bathmodon elephantopus;* cranium, side-view, from the Gallinas.
Plate VI.—*Bathmodon elephantopus;* cranium, from below, from the Gallinas.
Plate VII.—North Fork Cañon, White Mountain Creek, Arizona.
Plate VIII.—Oak Grove, White Mountain range, Arizona.
Plate IX.—Ruin in the pueblo San Juan, showing walls of room in third story.

Appendix F.—(Meteorology and hypsometry.)

Diagram showing effects of temperature upon aneroid barometers.

Appendix G 1.—(Geology.)

Fig. 1.—Strata of feldspathic porphyry and gneiss on Sangre de Cristo Creek, near the pass.
Fig. 2.—Outcrop of Jurassic strata near Abiquiu.
Fig. 3.—Diagrammatic sketch of the Zandia Mountains, looking east by south across the village of Placita.
Fig. 4.—South wall of the Cañon Cangilon.
Fig. 5.—View of a Jurassic anticlinal, looking north.
Fig. 6.—Triassic mesa, bounded on the north by Jurassic bluffs capped by gypsum, immediately east of the anticlinal of Fig. 5.
Fig. 7.—View of curved hog-back of Triassic sandstone, with red peak, and the red beds of the Trias, forming part of the Gallinas Mountains, looking north by east.
Fig. 8.—Bad lands of the Trias, looking southeast.
Fig. 9.—View of Triassic beds of Figs. 7 and 8, looking northeast.
Fig. 10.—View of Nacimiento and adjacent mountains, looking southeast from the Eocene bluffs.
Fig. 11.—Synclinal in Cretaceous, opposite the Cañoncito de las Vegas.
Fig. 12.—Section of Cretaceous, at locality of Fig. 11.
Fig. 13.—Hog-back and lignite of Cretaceous, at Cristona, looking south.
Fig. 14.—View from hog-back of Cretaceous, from ruin No. 1, looking west-northwest.
Fig. 15.—Eocene bad-land butte, looking south from camp No. 2.
Fig. 16.—View of the Eocene bad-lands, looking north from second camp west of the Gallinas.
Fig. 17.—Bad lands of the Wahsatch beds, near camp No. 2.
Fig. 18.—Section nearly east and west from the Gallinas to the Eocene bluffs.

Appendix G 2.—(Geology and mineralogy.)

Fig. 1.—Section of the Arkansas valley, five miles above Pueblo, Colo., showing irregular stratification.
Fig. 2.—Section showing the relative position of the Carboniferous strata.
Fig. 3.—Section of the bed of Rio de San José, two miles east of Laguna, showing the basaltic flow.
Fig. 4.—Section showing the upheaved strata in the Gallinas Valley, near the Las Vegas Hot Springs.

Appendix I.—(Zoology.)

Diagram of ruins in the valley of the Rio Chama, near Abiquiu, N. Mex.

Appendix I 1.—(Ethnology, &c.)

Fig. 1.—Ground-plan of house No. 3.
Fig. 2.—Ground-plan of houses Nos. 4 and 5 and profile of No. 4.
Fig. 3.—Ground-plan of house No. 6.
Fig. 4.—Ground-plan of house No. 7.
Fig. 5.—View of house No. 24.
Fig. 6.—Indian rock-etchings.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
In the field, June 30, 1875.

GENERAL: I have the honor to submit the following report upon geographical surveys west of the one hundredth meridian for the fiscal year ending June 30, 1875.

The States and Territories of California, Nevada, Nebraska, Utah, Arizona, Colorado, New Mexico, Wyoming, and Montana had been entered at the close of the season of 1874, during the several years' operations of the survey.

Of the political divisions lying west of the one hundredth meridian, where actual field-work has not been done, are Oregon and the Territories of Washington and Idaho, and portions of Dakota, Kansas, and Texas.

When ordered, detached or conjoined work may be carried on in one or all of the above, if means and skilled assistants can be made available.

The Territory of Alaska was not included in the scheme founded upon the basis of a topographical atlas of the territory of the United States west of the one hundredth meridian that was shortly after the close of the season of 1871 submitted to, and approved by, the Chief of Engineers, and the Honorable the Secretary of War. A similar method of dividing up its area might be applied in its future survey, with such scale for the resultant maps as shall be dictated by the wants of the Government.

SUMMARY OF FIELD AND OFFICE OPERATIONS.

At the close of the preceding fiscal year, the parties for field-operations had been organized and were commanded as follows:

Main and supply division.—In charge of myself, assisted by Lieut. C. W. Whipple, Third United States Artillery, as executive officer.

First division.—Party No. 1, Lieut. W. L. Marshall, Corps of Engineers; party No. 2, First Lieut. Rogers Birnie, jr., Thirteenth United States Infantry. *Second division.*—Party No. 1, First Lieut. Philip M. Price, Corps of Engineers; party No. 2, First Lieut. Stanhope E. Blunt, Thirteenth United States Infantry.

The field of operations embraced certain areas in Southern and Southwestern Colorado, and Northwestern New Mexico, more specifically described further on, and shown upon the progress-map herewith. In addition to the parties before mentioned, a small astronomical party, in charge of Dr. F. Kampf, observer, assisted by two meteorological observers, determined the astronomical co-ordinates of Las Vegas and Cimarron, N. Mex.; Julesburg, Colo.; Sidney Barracks and North Platte station upon the Union Pacific Railroad, Nebraska, sending signals to the observatory of the survey at Ogden, in charge for the season of Assistant John H. Clark.

A special paleontological and zoological party, in charge of Acting Assistant Surgeon H. C. Yarrow, United States Army, with a subparty under Prof. E. D. Cope, for making collections and geological and paleontological investigations, principally in Northern New Mexico.

A special party, in charge of Acting Assistant Surgeon J. T. Rothrock, United States Army, for making collections in Southern Arizona.

Nearly all of these parties were disbanded at Pueblo, Colo., in December; the officers and professional assistants returning to Washington, where they were actively engaged during the winter in the preparation of field-results for final publication.

Executive and special reports of officers and professional assistants are herewith. The organization of field-parties for the present season is as follows:

California section.—Party No. 1: In charge of myself, from which a special party, under Lieut. C. W. Whipple, Third United States Artillery, has been detached for independent work during the entire season, as executive officer and field astronomer; Acting Assistant Surgeon H. C. Yarrow, United States Army, medical officer and zoologist; Acting Assistant Surgeon J. T. Rothrock, United States Army, medical officer and botanist. Party No. 2: First Lieut. Rogers Birnie, jr., Thirteenth Infantry, executive officer and field-astronomer. Party No. 3: First Lieut. Eric Bergland, Corps of Engineers, executive officer and field-astronomer.

Colorado section.—First Lieut. Wm. L. Marshall, Corps of Engineers, in general charge, and executive officer and field-astronomer of party No. 1. Party No. 2: First Lieut. C. C. Morrison, Sixth United States Cavalry, executive officer and field-astronomer. Party No. 3: First Lieut. Wm. L. Carpenter, Ninth United States Infantry, executive officer and naturalist.

To all of these parties are attached the requisite number of topographers, geologists, recorders, guides, packers, laborers, &c.

Paragraph 3, Special Orders No. 87, Adjutant-General's Office, current series, sets forth the facilities to be afforded through the supply departments of the Army in furtherance of the objects of the survey, and details two 1st class privates of the Engineer Batallion, (who acted as barometoic recorders,) and an escort of one non-commissioned officer and seven privates, (selected from Company G, 12th Infantry,) from the Military Division of the Pacific, who, having reported at Los Angeles, Cal., were distributed among the working-parties of the California section.

The field work of the California and Colorado sections has been commenced both at Los Angeles, Cal., and Pueblo, Colo., as initial points, and will be prosecuted over areas of portions of atlas-sheets 61, 69, 77, 78, 72, and 73 in the main, while a special party, under Lieutenant Bergland, has been dispatched to the Colorado River to ascertain the feasibility of its diversion from its present bed for the purposes of irrigation, in accordance with a special letter of instructions from the Department. In this connection, work of considerable geographical importance will be carried on, and preliminary information gathered, upon which to base a plan to fully determine the practicability of utilizing this great river by directing its waters to a new channel, along which all admissible lakes or reservoirs could be formed. This special examination having been intrusted to my charge, the detailed arrangements and instructions necessary to the instrumental and other measurements thereof have been committed to a party under Lieutenant Bergland, and a report of progress will be submitted at the close of the field-season of his party, which, in view of the severity of the climate in the comparatively arid sections bordering upon the Colorado, will not be prolonged beyond October 15.

The several parties now successfully engaged in the field resume operations this year under the most favorable circumstances, the organization, especially as regards perfection of methods and instruments, and

additional experience of observers, having advanced and strengthened as heretofore within the year.

The officers of the survey were employed during the office-season as follows: First Lieut. Wm. L. Marshall, Corps of Engineers, in charge of field astronomical and geodetic computation and meteorological work, assisted by Lieut. Rogers Birnie, jr., Thirteenth United States Infantry, and Lieut. S. E. Blunt, Ordnance Department, until relieved; First Lieut. Philip M. Price, Corps of Engineers, in charge of topographical work and general supervision of property, including instruments and instrument-record; Second Lieut. C. W. Whipple, Third United States Artillery, in charge of draughting work.

Acting Assistant Surgeon J. T. Rothrock, United States Army, in examination of, and report upon, the collections made by the party under his charge during the field-season, and preparation of material for vol. VI (Botany) of the survey-reports.

Acting Assistant Surgeon H. C. Yarrow, United States Army, in charge of zoological work and preparation of reports thereon, assisted by Mr. H. W. Henshaw, (ornithologist.) Subreports from these officers, also from Prof. E. D. Cope, on ruins of ancient buildings observed in New Mexico; on geological survey of field-season of 1874, including paleontology of Santa Fé marls, are herewith.

Prof. C. A. White was also engaged in preparing report upon invertebrate fossils; and at this writing the report, with plates, is ready for the printer and engraver, and will appear in vol. IV of the survey-reports.

Assistant Dr. F. Kampf was engaged in the reduction and computation of astronominal work and preparation of observations for final publication. Assistants Frank Carpenter, F. A. Clark, W. A. Cowles, F. O. Maxson, Louis Nell, W. H. Rowe, J. C. Spiller, E. J. Sommer, and Gilbert Thompson, in the reduction and plotting of field-notes; Dr. Oscar Loew in the analysis of soils, minerals, mineral-waters, plants, &c., and preparation of reports thereon; also reports upon Indian languages and ancient ruins. Charles Herman and J. C. Lang, in the projection, line drawing, lettering, &c., of maps; and Mr. J. E. Weyss in drawing the mountain work upon the final maps; Hospital-Steward T. V. Brown, United States Army, and Mr. F. M. Lee, in the reduction of meteorological observations and computation of altitudes; and Messrs. Francis Klett, Geo. M. Lockwood, J. B. Minnick, J. D. McChesney, and W. D. Wheeler, in the settlement of money and property accounts, correspondence, distribution of reports, maps, &c.; Mr. T. H. O'Sullivan, in printing photographs, maps, &c.

The following is a general summary of field and office work during the year:

FIELD.

Main telegraphic longitude stations	5
Latitudes determined:	
Main stations	6
Sextant stations	50
Main triangulation stations occupied	51
Topographical stations occupied	103
Number of miles traversed	11,440.25
Number of main barometrical stations occupied	572
Number of aneroid stations occupied	3,335
Number of botanical specimens collected	9,000
Number of specimens of mammals, fish, reptiles, and insects collected	20,155
Number of specimens of birds collected	1,227
Number of other ornithological specimens collected	83
Number of lots geological and mineralogical specimens collected, (including mineral-waters)	497

OFFICE.

Number of astronomical positions computed	55
Number of sheets plotted	15
Number of cistern-barometer altitudes computed	872
Number of aneroid-barometer altitudes computed	3,965
Number of atlas-maps (1 inch to 8 miles) published	8
Number of atlas-maps ready for publication	3
Number of atlas-maps partially completed	2
Number of atlas-sheets (1 inch to 8 miles and 1 inch to 4 miles) in course of preparation	13
Number of reports published	5
Number of reports in course of publication	2
Number of reports nearly ready for publication	4
Number of maps distributed: { 254 sets of 8 sheets each; 486 sets of 12 sheets each }	7,864

PERSONNEL.

The following changes of officers upon the work have occurred during the year: Lieut. Philip M. Price, Corps of Engineers, relieved May 5, 1875; Lieut. Stanhope E. Blunt, Ordnance Corps, relieved December 30, 1874; Lieut. Eric Bergland, Corps of Engineers, joined May 21, 1875; Lieut. C. C. Morrison, Sixth United States Cavalry, joined June 5, 1875; Lieut. W. L. Carpenter, Ninth United States Infantry, joined May 22, 1875; and the following assistant engineers have been employed:

ASTRONOMICAL OBSERVERS.

Dr. F. Kampf, the whole year.
John H. Clark, from July 7 to Nov. 7, 1874.

TOPOGRAPHERS.

R. J. Ainsworth, July 7 to Sept. 5, 1874.
W. R. Atkinson, July 7, 1874, to Feb. 28, 1875.
Frank Carpenter, the whole year.
W. A. Cowles, July 7, 1874, to close of year.
F. A. Clark, July 11, 1874, to close of year.
F. O. Maxson, July 9, 1874, to close of year.
Louis Nell, the whole year.
Wm. H. Rowe, July 9, 1874, to May 31, 1875.
E. J. Sommer, July 1, 1874, to May 9, 1875.
J. C. Spiller, July 11, 1874, to close of year.
Gilbert Thompson, the whole year.
Geo. H. Birnie, May 15, 1875, to close ot year.
John A. Hasson, May 22, 1875, to close of year.

BAROMETRIC RECORDERS.

Bernard Gilpin, July 1, 1874, to Dec. 15, 1874.
F. M. Lee, the whole year.
Geo. M. Dunn, May 5, 1875, to close of year.
F. Brockdorff, May 15, 1875, to close of year.
Wm. C. Niblack, May 20, 1875, to close of year.
Frank Holland, June 1, 1875, to close of year.
Allston C. Ladd, May 22, 1875, to close of year.

GEOLOGISTS.

G. K. Gilbert, July 1, 1874, to Sept. 30, 1874.
A. R. Conkling, May 18, 1875, to close of year.
Jules Marcou, April 1, 1875, to close of year.
Douglas A. Joy, during month of June, 1875.

PALEONTOLOGISTS.

Prof. E. D. Cope, July 7, 1874, to close of year.
Dr. C. A. White, July 18, 1874, to May 25, 1875.

MINERALOGIST AND CHEMIST.

Dr. Oscar Loew, the whole year.

COLLECTORS IN ZOOLOGY.

Chas. E. Aiken, July 22, to October 19, 1874.
H. W. Henshaw, (ornithologist,) the whole year.
W. G. Shedd, July 23 to Nov. 13, 1874.
Chas. T. Shoemaker, May 25, 1875, to end of year.

PHOTOGRAPHER.

T. H. O'Sullivan, July 23, to Nov. 30, 1874.

DRAUGHTSMEN.

Charles Herman, the whole year.
J. C. Lang, the whole year.
J. E. Weyss, the whole year.

CLERICAL.

F. Klett, the whole year.
George M. Lockwood, the whole year.
J. B. Minnick, the whole year.
J. D. McChesney, Nov. 27, 1874, to end of year.
W. D. Wheeler, the whole year.

The only casualty during the year was that of R. J. Ainsworth, topographer, who lost his life by the accidental discharge of his pistol, at Tierra Amarilla, N. Mex., on the 4th of September, 1874. The circumstances of his melancholy death are stated by Dr. Yarrow (in charge of the party in which Assistant Ainsworth was serving) in his report. (See Appendix I 1.)

Hearty assistance and co-operation have been rendered and maintained by each and all of the members of the survey.

Thanks are due to Dr. Elliott Coues, United States Army, Prof. E. T. Cresson, Messrs. Theo. L. Mead, W. H. Edwards, R. H. Stretch, C. R. Osten-Sacken, Henry Ulke, Dr. P. H. Uhler, Prof. Cyrus Thomas, and Dr. Hagen, for kind assistance in the compilation of data derived from zoological collections and observations in the field. The officers of the Smithsonian Institution and several other gentlemen connected therewith have rendered valuable assistance, as have also Dr. George Vasey, of the Agricultural Department, and Mr. Sereno Watson, of the Botanical Gardens, Cambridge, Mass. It becomes a pleasure to speak of the cheerful co-operation of many officers of the Quartermaster's, Subsistence, and Medical Departments, and Ordnance Corps, and also that of the commanders of the several military divisions, departments, districts, and posts touched during the operations of the survey. The officers of the United States Naval Observatory and United States Coast Survey have likewise extended kind assistance.

Despite the many obstacles that have militated against the full and fair development of the mapping on a large scale of the mountains of the western interior, this work has gone on at an energetic and successful pace, which from year to year (as its objects and results have become more patent) it is believed has won for it a better recognition.

The delineation of the surface of the western mountain-region, and a description of its resources, offer a wide and extensive field, in which, as I have endeavored by former reports to show, the Government by right of domain, and for want of knowledge, is most largely interested; and it is only by the constant attack of bodies organized for systematic work that the physical structures of the waste and unknown lands along the untenanted mountain-frontiers shall be brought to light and made known not only for the uses of the Government, but for all the people and for all time.

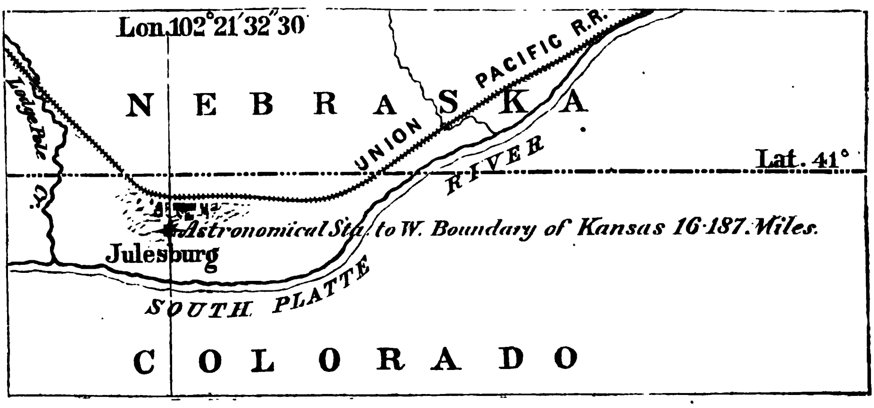
ASTRONOMICAL.

In this branch of the survey, the work during the year has comprised the determination of the astronomical co-ordinates of the main stations at Las Vegas and Cimarron, N. Mex., Sidney Barracks and North Platte, Neb., and Julesburg, Colo.

The usual temporary field-observatories and observing-piers have been erected at these points, and Dr. F. Kampf and party conducted the observations, communicating with the observatory of the survey at Ogden, Utah, in charge, for the season, of assistant John H. Clark.

Time-signals were transmitted free of charge over the wires of the Western Union Telegraph Company from Las Vegas and Cimarron, N. Mex., and over those of the Atlantic and Pacific Telegraph Company from the other localities upon the Union Pacific Railroad.

The results of the observations taken at Julesburg, near the station on the Union Pacific Railroad, and on the southern side of the railroad-track, show this point to be south of the forty-first parallel of north latitude, or in Colorado instead of Nebraska, as it has heretofore been shown upon some of the published Government maps. The situation of the station in relation to the Union Pacific Railroad and boundary is shown below.



The usual meteorological observations have been kept up by the party operating at these points. A comparison of times was had between the survey observatory at Ogden, and United States Naval Observatory at Washington, D. C., by Assistant John H. Clark, and Prof. James R. Eastman, United States Navy.

The necessary sets of observations for a determination of the difference in longitude were made, and thus a third comparative result for the longitude of the east pier in the west observing-room at the Ogden observatory has been obtained; those previous having been by connection with the United States lake survey at Detroit, Mich., and with the pier established by the United States Coast Survey in the Mormon Temple grounds in Salt Lake City, Utah. Another set of observations was also taken to serve as a comparison with the latitude previously obtained for the position of the instrument upon this pier.

In addition to the positions above given, the astronomical station occupied by Lieut. E. H. Ruffner, Corps of Engineers, at South Pueblo, Colo., in 1873, and of which no latitude had been published, was rebuilt, and a set of zenith-telescope observations made thereat. The report, with result, is herewith.

PUEBLO, COLO.

Longitude: 104° 36′ 57″.53.
Latitude: 38° 15′ 42″.84 ± 0″ 17.

The station is situated on the top of the bluff near the railroad-station in South Pueblo. The instrument was the same used at the previous stations of Las Vegas and Cimarron, N. Mex. The longitude as given above is derived from geodetic work, in connection with our primary astronomical stations at Labran, Colorado Springs, and Trinidad, Colo., executed in the seasons of 1873–'74.

Observations and computations for latitude of Pueblo, Colo.

SEPTEMBER 14, 1874.

No. of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half-sum of declination.	Corrections. Micrometer and refraction.	Corrections. Level.	Corrections. Meridian.	Latitude.
	t. d.	d.	d.		° ′ ″	′ ″	″	″	° ′ ″
6780	7 46.0	24.0	11.0						
6794	6 25.2	4.2	30.7	....	38 16 31.3	—0 46.6	—3.1	....	38 15 41.6
6824	10 36.6	35.0	— 0.3						
6827	14 90.0	....	37.3	....	12 51.2	+2 54.7	—1.1	....	44.8
6835	3 76.6	....	37.5	....	19 59.2	—4 14.4	—1.2	....	43.6
7140	11 67.9	....	— 1.0						
7166	2 52.0	— 2.0	....	....	9 52.2	+5 53.0	+0.5	....	45.7
7213	13 54.0	42.0	....						
7260	1 25.8	....	43.3	....	7 49.7	+7 53.3	—0.6	....	42.4
7320	2 90.0	4.9	32.0						
7336	13 43.0	28.3	8.7	....	9 0.8	+6 44.8	—1.7	....	43.9
7365	4 61.2	31.4	5.5						
7410	11 23.8	2.0	35.5	....	11 31.2	+4 15.4	—1.8	....	44.8
7505	0 68.8	16.0	22.0						
7524	10 27.0	18.0	20.0	....	21 52.7	—6 9.3	—1.9	....	41.5
7571	2 35.0	7.3	29.7						
7589	13 50.4	25.8	12.0	....	22 53.0	—7 9.9	—2.0	....	41.1
7674	8 96.5	26.9	12.0						
7689	17 26.5	8.0	31.8	....	10 25.3	+5 19.9	—2.1	....	43.1
7778	6 86.8	22.9	16.0	....	19 6.0	—3 21.1	—0.4	....	44.5
7782	15 10.9	22.9	16.0	....	24 23.0	—8 38.7	—0.4	....	43.9
7807	1 65.0	15.3	24.0						

SEPTEMBER 15, 1874.

No. of star.	Micrometer-readings.	Level. N.	Level. S.	Remarks.	Half-sum of declination.	Corrections. Micrometer and refraction.	Corrections. Level.	Corrections. Meridian.	Latitude.
6824	6 75.8	17.8	21.0	30ᵐ p. m.					
6835	0 3.0	22.0	16.8	....	38 19 59.2	—4 19.3	+0.5	+0.1	38 15 40.5
6924	6 84.5	28.0	12.0						
6933	6 72.0	12.5	27.5	....	15 45.9	—0 4.8	+0.2	....	41.3
6967	9 31.2	19.0	21.2						
6986	3 78.0	21.2	19.5	....	12 9.8	+3 33.3	—0.1	....	43.0
7006	5 7.6	24.7	15.8						
7022	8 60.1	17.0	23.5	....	17 58.3	—2 15.9	+0.5	....	42.9
7073	3 39.5	20.0	21.3						
7114	12 2.1	20.0	22.0	....	21 14.4	—5 32.4	—0.5	....	41.5
7140	11 8.9	10.4	31.0						
7166	2 0.0	29.8	12.3	....	9 52.4	+5 50.3	—0.7	....	42.0
7213	12 70.0	33.5	7.8						
7260	0 48.0	7.0	34.5	40ᵐ p. m...	7 49.9	+7 51.1	—0.4	+0.1	40.7
7320	3 14.5	24.0	18.5						
7336	13 69.5	7.0	35.8	....	9 0.6	+6 46.6	—5.4	....	41.8
7365	3 89.9	16.0	26.5						
7410	10 44.9	23.5	19.0	....	11 31.4	+4 12.4	—1.4	....	42.4
7505	— 0 74.6	14.3	19.5						
7524	8 82.5	30.3	13.0	....	21 52.9	—6 8.9	+0.5	....	44.5
7571	1 12.3	8.0	34.5						
7589	12 35.2	36.2	7.0	....	22 53.2	—7 12.9	+0.6	....	40.9
7644	2 81.5	22.0	21.3						
7689	11 7.2	21.0	23.0	....	10 25.6	+5 18.2	—0.3	....	43.5
7733	6 17.5	28.0	15.4						
7754	8 88.5	15.3	28.5	....	17 27.3	—1 44.5	—0.1	....	42.7
7778	7 22.0	43.3	0.5	....	19 6.3	—3 23.9	+0.6	....	43.3
7782	15 44.1	43.0	0.6	....	24 23.3	—8 40.8	+0.5	....	43.0
7807	1 93.0	2.0	42.2						

Observations and computations for latitude of Pueblo, Colo.—Continued.

SEPTEMBER 16, 1874.

No. of star.	Micrometer-readings.	Level.		Remarks.	Half-sum of declination.	Corrections.			Latitude.
		N.	S.			Micrometer and refraction.	Level.	Meridian.	
	t. d.	*d.*	*d.*		° ′ ″	′ ″	″	″	° ′ ″
6824	6 44.7	31.3	9.6						
6835	— 0 24.9	11.0	29.8	....	38 19 59.4	—4 18.1	+0.7	....	38 15 42.0
6967	9 34.2	7.5	33.7						
6986	3 79.5	37.0	5.0	....	12 10.0	+3 33.8	+1.3	....	45.1
7006	5 37.6	22.0	20.0						
7022	8 91.3	23.0	19.4	....	17 58.5	—2 16.3	+1.3	....	43.5

Latitude, 38° 15′ 42″.84 ± 0″.17.

The reports upon the results of the observations of the past field-season are now ready, and will appear as a part of volume II of the quarto reports.

The positions of the main stations are herewith given.

GEOGRAPHICAL POSITIONS.

Transit-instrument for chronometer-error; zenith-telescope for latitude, (Talcott's method); telegraphic time-signals for difference of longitude.

Year.	Station.	Atlas-sheet number.	OBSERVER, Sending. Receiving.	COMPUTER, Sending. Receiving.	REPORT arranged by—	LONGITUDE. No. of ex-changes.	LONGITUDE. West from Greenwich.	LONGITUDE. Probable error.	LATITUDE. No. of pairs of obs.	LATITUDE. North.	LATITUDE. Probable error.	Altitude above sea-level.	Remarks.
							° ′ ″	″		° ′ ″	″	*Feet.*	
1874	Cimarron, N. Mex	70 (A)	Dr. F. Kampf. J. H. Clark	Dr. F. Kampf.	Dr. F. Kampf.	3	104 54 59.04	±0.20	69	36 30 10.01	±0.09	6350.4	Checks base-line measured 1873.
1874	Julesburg, Colo	45	Dr. F. Kampf. J. H. Clark	Dr. F. Kampf.	Dr. F. Kampf.	5	102 21 32.30	±0.43	63	40 59 07.63	±0.04	3500.0	Valuable as a point of departure in checking surveys north or south of the Union Pacific Railroad.
1874	Las Vegas, N. Mex	75 (A)	Dr. F. Kampf. J. H. Clark	Dr. F. Kampf.	Dr. F. Kampf.	3	105 13 27.57	±0.10	99	35 35 27.66	±0.07	6418.0	Checks base-line measured 1873.
1874	North Platte, Nebr	45	Dr. F. Kampf. J. H. Clark	Dr. F. Kampf.	Dr. F. Kampf.	3	100 45 53.14	±0.95	68	41 08 18.33	±0.06	2790.0	On Union Pacific Railroad.
1874	Sidney Barracks, Nebr	44	Dr. F. Kampf J. H. Clark	Dr. F. Kampf.	Dr. F. Kampf.	5	102 58 12.68	±0.45	80	41 08 36.75	±0.05	4073.0	On Union Pacific Railroad.

Those determined by other astronomical methods, triangulation, and trigonometrical processes, from the years 1869 to 1874 inclusive, will appear in the form of condensed tables of geographical positions, altitudes, distances, magnetic variations, &c., the manuscript for which is in course of preparation.

Connection was had with a point selected at the camp of organization of the expedition of 1874 with the monument at South Pueblo, Colo., and the trial sextant-observations for latitude, here made by the officers in charge of parties, were compared.

The finished appurtenances and the necessary repairs to the observatory have been completed, excepting the middle room and the dome, for which a moderate sum should be authorized as soon as the same can be made available.

I have also to recommend that a room adjoining the middle room to the north shall be constructed for the purposes of meteorological observations and storage of instruments.

As has been customary, the several officers of the Corps of Engineers and of the line of the Army in charge of parties have made observations for time and latitude at proper points, computing the observations in the Office in Washington, D. C., upon their return from the field. No additional points have presented themselves where telegraphic connections for comparison with sextant and chronometer observations for time and latitude could be employed, but it is intended to perfect the methods, whereby, with the most portable instruments and with the proper accessories, determinations for longitude and latitude can be made sufficiently accurate to serve as initial points for measured and developed bases, at points remote from present routes of convenient transportation.

When the telegraph now in process of construction, under the Signal-Service of the War Department, from Santa Fé, N. Mex., to San Diego, Cal., via the Rio Grande, Camp Grant, and Tucson, Ariz., and Fort Yuma, Cal., is completed, convenient points, to be thus occupied, will be selected.

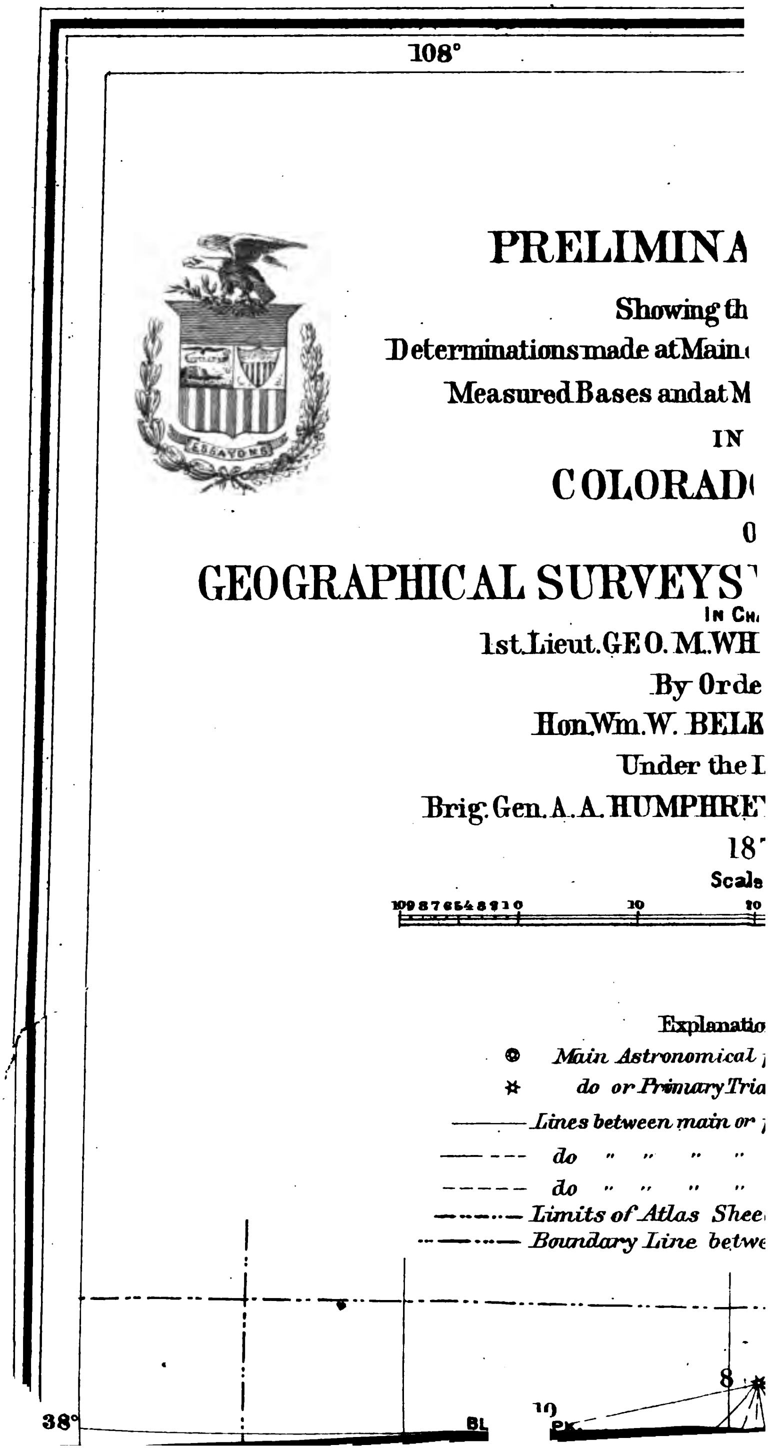
The quadrilateral telegraphic communication, which will extend from Ogden, Utah, by Central Pacific Railroad, to San Francisco, Cal.; thence, via Southern Pacific Railroad or Coast Line, to San Diego, Cal.; thence, via Tucson, Ariz., to Santa Fé, N. Mex.; thence to Denver, Colo.; thence to Cheyenne, Wyo.; and thence, via Union Pacific Railroad, to close the circuit at Ogden, will be taken advantage of to check astronomic determinations at specific points that have been, or may be, occupied on that part of the line extending from San Diego, Cal., to Santa Fé, N. Mex.

It is advisable, in furtherance of this most important class of work of the survey, to select at once at least two locations, one to be near the east base of the Rocky Mountains, another to the west of the Sierra Nevada, and both to the south of the fortieth parallel, at which the foundations for permanent field-observatories, similar to the one at Ogden, shall be laid at an early day.

I have to recommend for the first Denver, Colo., and for the second Los Angeles or San Diego, Cal.

GEODETIC AND TOPOGRAPHICAL.

Measured and developed bases, each connected with the belts of triangles that reach from Denver, Colo., on the north, to Santa Fé, N. Mex., on the south, and extend from the east base of the Rocky Mountain ranges to near the western boundary of Colorado and New Mexico, have



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been measured at Pueblo and Trinidad, Colo., and Cimarron, Fort Union, Las Vegas, and Santa Fé, N. Mex. After the connections shall have been completed at the close of the present field-season, the geographical positions at the vertices of the main and secondary triangles should be computable from the extremity of any of the above bases as initial points, thus giving several results for each position arrived at from original and independent data. The extremities of the bases at the above-mentioned points are joined with the main astronomical points that have been established in their immediate vicinity. These points have all been carefully marked by enduring monuments, and the extension of the work can be developed from each in all directions at will.

Angles of the main triangles have been measured by four of the moving field-parties, and the connections completed over large areas in Colorada and New Mexico, with the exception of a few points to be occupied early during the present season.

A preliminary sketch, based upon observations made by assistants L. Nell, G. Thompson, F. A. Clark, F. O. Maxson, J. C. Spiller, and E. J. Sommer, members of parties under command of Lieutenants Marshall, Tillman, Whipple, Price, Birnie, Blunt, Hoxie, and myself, confined to an exhibit of the main or primary triangulation, and showing its extension in the Colorado section of the work, is here introduced. The secondary triangles, other trigonometric connections, and intermediate astronomical check-stations are not shown, as the data obtained for their determination are not yet all reduced.

Lists of geographical positions of the several orders of value will be given in the special publication now being prepared. (See Appendix K, on publications.)

This map, or sketch, is of great value for field and office use, in connection with the filling-in of all essential details within the area already embraced by the main triangulation, and also as an index to future connections westward.

The points occupied and to be occupied in Colorado during the present field-season were selected in pursuance of my project submitted to and approved by the Chief of Engineers and the honorable the Secretary of War, being a part of the system of triangulation and detailed map-representation pertaining to certain of the rectangles lying within the region to be occupied as proposed in an earlier project (April 3, 1873) for the systematic and connected prosecution of the work, and which received the sanction of the Chief of Engineers and the Secretary of War after Congress had made appropriation for continuing the survey for the ensuing fiscal year.

The geographical positions of the main astronomical stations, together with those of the extremities of the measured and developed bases, and of the vertices of the main triangles, carefully computed, form the mathematical basis, and, in the early stage of the construction of the map, are most essential; while the intermediate points, obtained in the secondary triangulation by connection with three well-established points, by latitude-checks, or from meanders of the roads, trails, streams, &c., serve to locate all necessary points that are selected in such close conjunction as to admit of the sketching of the intermediate mountain-topography, so that as far as practicable from the resultant data conjectural contours of the ground expressing differences of elevation of 250 feet, each referable either to an arbitrary or common plane, can be delineated.

In limited areas where the sectionizing of the public lands has been accomplished, usually in mountain-valleys encompassed by the geograph-

ical work of the survey, connection with the stakes or other marks is had when practicable, and minor details of roads, trails, rivers, creeks, lakes, springs, &c., can be introduced from the Land-Office plats with sufficient accuracy.

The details gathered the past season are sufficient for the construction of sheets of the area occupied upon a scale of one inch to four miles, while a portion of the so-called San Juan mining-region, intricate in topography, and likely to become of importance through its mining prospects, will be mapped upon a scale of one inch to two miles; indeed, for a clear and vivid representation of the rugged wilderness of mountains lying in Southwestern Colorado, no scale less than one inch to one mile is adequate.

NOTE.—The field-work of 1874 completes the connection of the areas of New Mexico and Colorado over which the surveyed portions were partially joined in 1873, while at the close of the season of 1875, the areas mapped will stretch in a belt from the Pacific Ocean to the eastern base of the Rocky Mountains, or westward from the Pecos to the Pacific.

The area embraced during the past season has not been so large as in former years. Another step has been made in the direction of a more perfect and refined geodetic survey; and the system once established, the results as to areas mapped in a manner that will require no future change, except in details incident to the development of the country, will vary, the force remaining constant, according to the physical construction of the ever-shifting panorama of mountain, valley, and plain found along each parallel of latitude within the longitudinal limits of the survey.

NOTE.—The number of sheets, 19 by 24 inches, required to express the topography of the United States, excepting the Alaska addition, lying west of the one hundredth meridian, upon a scale of one inch to one mile, is approximately 6,000. If each of the 95 sheets projected to form the atlas of that area upon a scale of one inch to eight miles were complete, the number would be 6,080 sheets.

When practicable, initial monuments, marking a point of determinable position as to longitude, latitude, and altitude, the meridian-line through which has been laid out, have been erected in mining-camps about to be opened, and where surveys of the mineral-lands, and other surveys, both superficial and underground, are about to be made. More attention will be given from year to year to the selection of points of initial value in the future survey of the mountain-ranges in greater detail, or those portions of them from which the precious and other metals are to be extracted.

It would appear eminently proper to anticipate, since this work lies outside and in advance of the Land-Office surveys, the wants of this class of surveys at the time that they shall be extended largely into the more impassable mountain-sections, so that in the future the linear or rectangular connection over difficult lines may be avoided, or perhaps replaced by a triangular system to be made applicable to all classes of areas within the western mountain-regions.

From time to time, as mineral development on a large scale has brought to light a knowledge of the circumstances of ore-deposition in veins showing considerable permanence, and from which large annual products are obtained, more minute topographical surveys should be prosecuted, and the superficial and underground relations between the source of mineral-supply and the "country-rock" be obtained. In this connection, the plane-tables and other instruments convenient for the determination of contours over medium-sized areas will be brought into requisition.

In volume I will appear a clear and full exposition of the principal

features of the methods employed in the geographical portions of the work, with practical illustrations drawn from the material already at disposal.

While details under these methods will necessarily undergo many modifications, the system at present adopted will answer for the survey of all mountainous areas where natural objects, such as peaks, mesa-edges, buttes, volcanic cones, &c., appear within successive horizons at distances convenient for measurement, say not exceeding fifty miles for the sides of the main triangles.

The expedition of 1874 was divided into nine moving field-parties in addition to the observatory-party, and the office-force of draughtsmen and computers in Washington. These parties were respectively in charge of (1) myself; (2) Lieut. Wm. L. Marshall; (3) Lieut. P. M. Price;* (4) Lieut. C. W. Whipple; (5) Lieut. Rogers Birnie, jr.; (6) Lieut. Stanhope E. Blunt; (7) Acting Assistant Surgeon H. C. Yarrow;* (8) Acting Assistant Surgeon J. T. Rothrock; (9) Dr. F. Kampf.

The parties, including my own, those of Lieutenants Whipple, Price, Birnie, and Blunt, were so disposed as to work up a block of territory lying south of the latitude of the most northern of the Spanish Peaks, bounded on the east by 104° 07′ 30″ west longitude; on the south by a latitude-line passing through Santa Fé; and on the west approximately by the western boundary of Colorado and New Mexico.

These parties were assigned parallel strips from north to south, so far as compatible with the physical conformation of the areas of drainage into which they were to enter, with the exception of the one under Lieutenant Blunt, which had for its duties the survey of that part of the area above mentioned lying to the east of the summit-line of the ranges facing the plains, a well-marked profile running nearly due north and south throughout the entire area to be occupied during the season.

The party under Lieutenant Marshall was intrusted with the completion of triangulation extending over parts of Southern and Southwestern Colorado, and its connection with the base at Pueblo, that had been left the preceding season incomplete. Dr. Yarrow was placed in charge of a paleontological party operating within the area projected for the season, and a topographer was assigned to it. Dr. Rothrock, with a party organized to conduct certain barometrical observations and make collections in zoology and botany, operated westward and southwestward from Santa Fé, via Fort Wingate, N. Mex., Camps Apache and Grant, to Fort Bowie, Ariz., as a base of supplies. His mission proved successful. Dr. Kampf assumed charge of the party, of which he was chief observer, engaged in establishing the astronomical co-ordinates of the main stations referred to along the east base of the Rocky Mountain ranges and upon the Union Pacific Railroad. The parties, without exception, prosecuted their labors to the close of the working-season with vigor and success.

The continued improvement of instruments and methods in this branch, together with the valuable experience gained by assistants who have been connected with the work for several years, tend toward greater facility, and enhance the value of the work with each succeeding year. A reference to the executive reports of the several chiefs of parties will show, to some extent, the features of the country traversed and the amount of work accomplished.

* The party of Lieutenant Price was for a portion of the season in charge of Assistant Francis Klett, who assumed its duties in addition to his other labors; and that of Dr. H. C. Yarrow was assumed charge of by Prof. E. D. Cope, in September, the former having been ordered to the office in Washington.

The principal line of march of the party under my charge extended from Pueblo, Colo., on the Arkansas, via the regularly-traveled wagon-road, to Fort Garland, situated on the eastern side of the San Luis Valley, through the Sangre de Cristo Pass; thence westward, crossing the Rio Grande, to near the junction of San Antonio Creek with the Conejas River; thence to the source of the latter; having touched and followed, *en route*, for a small distance, a portion of the south fork of the Alamosa Creek, near its head; thence passing the continental divide via the head of the east fork of the Upper San Juan River to its meeting with the upper main fork, and onward to Pagosa Springs, from which point a trip was made to Tierra Amarilla and return.

The homeward journey doubled on the inward route to the confluence of the upper forks of the San Juan; thence in and out of the depressions, marking streams reaching either fork, until Del Norte, lying at the outer gate or entrance of the Rio Grande to the great San Luis Valley, was reached; thence following the usually-traveled route via Poncho Pass to Cañon City on the Arkansas.

The portion of the route from Pueblo to Fort Garland and its surroundings has often been described, while the resources of those sections in Colorado bordering upon the east base of the Rocky ranges* are receiving an outlet through the Denver and Rio Grande and other railroads that are fast being pushed to the southern boundary of this Territory, about to become a State.

Fort Garland, lying on a plane slightly elevated above the main valley between the Ute and Sangre de Cristo Creeks, and near their junction, is south and west about nine miles from old Fort Massachusetts, that was far more desirably located on Ute Creek, except as to its defensive position and convenience in reaching the valley of the Arkansas by any of the known passes of the Sangre de Cristo.

Up to the present time, the industries of the mountains and high valley portions of Southern and Southwestern Colorado have been but little developed, owing largely to their inaccessibility, and to the fact that traveled routes have left large areas comparatively untrodden except by the wagons laden with Government supplies, the wool-teams of the settler, mostly from New Mexico, the march of troops to and from stations, or in scouts in and out of mountain, valley, and cañon, the hardy prospector for hidden mineral wealth, or the nomadic tribes in their annual wanderings.

The later mineral discoveries in the San Juan region have awakened a new spirit of enterprise; new mail and stage routes reach out into the unknown parts; toll-roads have been built; and the earlier prospectors are, it is hoped, to be followed shortly by capital seeking investment, always most welcome in such remote regions.

The San Luis Valley was crossed to a camp on its western side, upon the banks of the Conejos, in the center of a cluster of Mexican towns, slumbering on the banks of this stream, and its neighbor, a tributary of the San Antonio Creek. The valley is fully forty miles wide along this line, which follows pretty closely the Trinchera, and crosses the Rio Grande below the mouth of the La Jara, and thence in close proximity

* Up to the time of Fremont's first expedition, and indeed later than that, in the popular mind, all the mountains lying west of the Mississippi and Missouri Rivers, especially those facing upon the great plains, were known as the "Rocky Mountains," and looked upon as one range. Later geographical researches have proven the existence of a number of ranges, and defined, in many cases, the boundaries of each. In speaking of more than one of these ranges that face the great plains, the term "Rocky ranges" will be used, in a sense of contradistinction to Coast range or ranges, where mention is made of one or several of the ranges facing the Pacific Ocean.

PLATE I.

T. Sinclair & Son, lith. Phila

PARK NEAR HEAD OF CONEJOS CAÑON, COLORADO.

to the northern bank of the Conejos. The map will show the limits entire of the great valley heretofore inappropriately called San Luis Park, and the streams that enter it, some sinking soon after their emergence from the cañons of the lower foot-hills, and others, especially those following from the San Juan range and to the south of Del Norte, reach the Rio Grande upon the surface. The soil on the western side is covered with a heavy, dark, pulverulent loam, well packed, being the direct result of denudation of the basaltic-capped foot-hills of the eastern flanks of the San Juan range. The part of the valley coming under my observation is limited to the route traversed, except at points where detours for observations were made.

The lands crossed, one and all, are susceptible of cultivation if water can be had, and will grow, with certainty, corn and the other cereals; and, approaching the Rio Grande, the altitude is not too great to allow maturing of the vegetables and more tender crops, with fruit. A proper system of irrigation, embracing the Rio Grande and creeks to the south that debouch from the San Juan range as far as to include the San Antonio, would do much in bringing under cultivation large tracts of fine soil, now of but little value even for grazing purposes, and all of which is most favorably situated, offering good natural slopes for the irrigating canals and ditches.

In this area, many of the agricultural productions that will find a ready market, should the mining-regions to the north and west be opened up successfully, can be grown.

By common consent of the most intelligent persons among the little settlements along the Conejos, the climate is unsurpassed; certainly during our stay of a few days in August in this vicinity nothing better could have been desired; the warmth of the day being succeeded by the still coolness of the night, that in the dry plateau-regions lends a charm inexplicable, and affords the settler a security from disease not usually appreciated.

The region of the San Luis Valley and its surrounding subdrainage basins, to the extended glades of many of which the name of parks might well be given, deserve a notice at the hands of foreign and domestic immigrants annually seeking homes in the western domain.

The Rio Grande, where crossed, at a ford a little to the north of the mouth of the Conejos, having low banks, marked only here and there by sparse cottonwoods and willows, was in August a stream between 30 and 40 yards in width, with swift current, and a maximum depth of about 4 feet. In times of high water, this ford is impassable except by swimming. Not far to the southward appear wide-mouthed cañons of basaltic-capped islands of sediments, formed during the Lake period, whose steep flanks approach farther on in cañon form.

The source of the Rio Grande is a region marked by some of the greatest elevations found in the heart of the continent, and in an area in which the annual amount of precipitation, pretty equally disposed throughout the seasons, is great, probably exceeding 40 inches, and reaching as high as 60 inches near the crests of the highest ridges. This river, of cañon rather than alluvial banks, meets in its course a large variety of geological strata in its long journey from a point on the continental divide in the Rocky Ranges to its meeting with the Gulf of Mexico, as the range of elevations in its profile from upward of 12,000 feet above tide to sea-level would indicate.

The Conejos takes its rise in the heart of the San Juan range, near the summit of the continental divide, and within stone-throw of the source of the South Fork of the Alamosa Creek, both of which join the

Rio Grande from the westward, and in their course, before debouching from the foot-hills, pass through a succession of parks and glades, (see Plate I,) limited on either side by cañon-walls often 700 and 800 feet in height, and defiles within these walls through which the streams wind with rapid currents.

The great variety of landscape, comprising forest-trees, shrubs, grasses, (delightfully green in contrast with the ashen-brown of the valley below,) lakelets, and springs, each affording a pleasing contrast to the eye, and anticipations for a campaign in which some of the esthetic accompaniments of camp-life, in contradistinction to the desert, might reasonably be expected.

However different the sequel that brought several comparatively sleepless nights on the greensward, with only the heavens for a covering, while the train with all its comforts seemed far away, may have been, I shall not soon forget the grandeur of the view from Prospect Peak, the first marked point of the foot-hills west from Conejos, that afforded a horizon made up of extended valleys and massive mountains on the one side, while to the westward, in the line of our route, lay the cragged summits of the San Juan range, and, in intervening vistas, a succession of forest, stream, and valley, most inviting.

The San Antonio Creek is a tributary of the Conejos from the south, while the La Jara, less important than either the Conejos or Alamoza, joins the Rio Grande between them. It was at the junction of the San Antonio and Conejos that Lieutenant (afterward General) Pike, while exploring for the source of the Red River, was captured by Mexican troops in 1807 and taken to Mexico. The remnants of a stockade erected as a protection against the Indians yet remain, and I was informed by credible authority that a peg bearing his name had been discovered near the source of Sangre de Cristo Creek, indicating that he entered the Rio Grande from the Arkansas, either by way of the Sangre de Cristo or Abeyta Pass, names unknown to the map of his route.

If we have a right to apply the term "park" to a series of natural objects picturesquely grouped in areas of considerable extent, and the right is exercised in the western mountain-region entered by the survey under my charge, after according the palm to the little valleys of drainage of the Upper Colorado Chiquito and the heads of Salt River, explored in 1873, my mind turns next to those situated among the foot-hills west of the central part of San Luis Valley, and in the valley of the Upper San Juan, where nature has accomplished on a grand scale a harmony that art could not improve, and the freshness and purity of which it might desecrate.

The timber noted has been principally pine and aspen, the former predominating. The highest peaks of the San Juan are bare, but the higher foot-hills and the mesa headlands standing out in the southern horizon, and the high mountains encircling the head of the San Juan, are plentifully supplied, as well as large areas along the creeks that enter the San Juan from the north as far west as Las Animas River.

The nutritious bunch-grass of the entire mountain-region, as yet unharmed by the tramp of sheep that, lower down the Rio Grande, have worn out parts of the ranges upon which they feed, is valuable to the prospector or future settler.

Evidences of large and small game have been plentiful, but no time could be devoted to hunting. Occasional messes of fine mountain-trout gave evidence of their plentifulness.

The divide between the waters of the Atlantic and Pacific was found

at the head of the South Fork of the Alamosa Creek, and by an abrupt and tortuous descent from the plateau-shaped summit the bed of the East Fork of the San Juan was reached, over a rugged trail marked out by this party, and not likely to be soon followed. A difficult journey brought us to the junction of the main and east forks of this stream, from whence a fine trail leads to Pagosa Hot Springs, a point selected as a rendezvous. After the usual mishaps and trials incident to exploration-life, camp was made at this picturesque locality. This point had been visited by the party of Lieutenant Marshall in 1873, and a party under Captain Macomb, of the Corps of Topographical Engineers, passed this section to the westward in 1859 in search of the junction of the Green and Grand Rivers. A description of these hot springs is given by Assistant J. J. Stevenson in volume III of the quarto Reports.

The principal southern tributaries of the San Juan River are the Rito Blanco and Navajo. They are crossed by the wagon-road constructed by Captain Macomb, of the Topographical Engineers, in 1859, on the road to Tierra Amarillâ, upon the Rio Chama, where are several small Mexican settlements within a radius of six or seven miles upon the main stream, or near the mouths of the East Fork and Nutritas Creek.

The ruins of the buildings at old Fort Lowell are characteristic, and show the rapid action of time as a demolisher. Remnants of the temporary shelter used as a summer cantonment on the banks of the San Juan, a little to the north of Pagosa Springs, were noted.

A shorter route, but impracticable for wagons after heavy rains, via Cañon Amagre, has been lately opened from the upper settlements about Tierra Amarilla, that passes to the eastward of Horse Lakes. Grass abounds along this entire distance, and timber on the high hills and mesas.

Below the mouth of the Navajo, the San Juan turns from, first a southerly, then southwesterly course, nearly to the westward, and soon receives from the north several important streams, including the Florida, Pinos, La Plata, Las Animas, and Mancos. So far as is known, no streams of any importance enter the river from either side to the west of the Mancos. The area bounded on the east and south by the San Juan from the junction of its forks to the mouth of the Mancos, on the west by the Mancos, and on the north by a line drawn from the point of the emergence of this stream from the higher mountains to the point first mentioned, is one great grazing-field, broken only at irregular intervals by groves, and not infrequently dense patches of timber. Its elevation precludes the cultivation of vegetables and corn, except in spots in the lower part of the narrow valleys of the streams; but the more hardy crops ought to mature by careful culture.

The mountains commanding the area described upon the north and east are covered nearly to their summits with a dense growth of pine, fir, and hemlock. Groves of aspen occur at elevations from six to eight and often nine thousand feet above sea-level.

The San Miguel, La Plata, and San Juan ranges, and other groups not yet properly classified, form this vast mountain amphitheater. Late prospecting has shown that surface indications of the precious minerals are promising at several points, some of which were visited. and reports thereupon, as far as the examinations could be made, will appear in due time.

In the month of September, the climate upon the Upper San Juan and its northern tributaries, at elevations not exceeding 8,000 feet, is delightful. The rains of July and August have ceased, and few clouds disturb

the clearness proverbial of the interior mountain-valleys and plateau-regions of Colorado and New Mexico.

The homeward route lay through a beautiful, park-like valley, reaching from the foot of the high mountains, from which the river breaks out through a precipitous cañon, to the junction of the two forks; thence the trail winds in and out, following the ridges dividing the drainage between these forks to a tributary of the South Fork of the Rio Grande, which is followed by a tortuous trail, often leading out of the valley of the stream to avoid cañons, to its mouth; and thence along the inclosed mountain-valley, through which flows the Rio Grande proper, to the little mining-town of Del Norte, facing the San Luis Valley. This trail had not apparently been frequented for years, but must have been of considerable importance to the Utes in their journeys in and out of the San Juan from the Rio Grande before their location upon reservations. Most of the summits passed were in excess of 10,000 feet above tide, and covered with heavy timber. Thunder and lightning, rain, hail, and snow-storms were our lot during this difficult trip, taken at the close of the month of September. Trails crossing passes of so great elevation in this section of territory become difficult later in the season than October 1; and the months of July, August, and September are the only ones of the year during which surveying parties obliged to climb the high surrounding peaks in succession can work with safety or advantage.

The large rain-fall has served to give fantastic shapes to the intricate drainage-areas shaped by the geological structure of this region, and determine for it an apparent inaccessibility, except along certain lines. The meager number of Indian trails in the area comprised by the heads of the Rio Grande, San Juan, and its northern tributaries, the Dolores, Uncompahgre, and Lake Fork of the Gunnison Rivers, in a section not long ago fully ranged over by certain of the Ute and Apache tribes, is a fair indication of the difficulties of traversing these regions, while the physical obstacles met by the parties in their clamberings through these mountains could only be hinted at in long-drawn itineraries of their routes, which time, space, and the scope of the reports of the survey alike forbid.

The South Fork of the Rio Grande, although dignified in title, is insignificant in comparison with the main stream that it joins. It is simply the largest creek that enters the Rio Grande between its source and debouchure into the San Luis Valley.

From Del Norte our route followed along the northwest arm of San Luis Valley, via Saguache, and thence across Poncho Pass and the creek of that name to the South Fork of the Arkansas, and thence to the end of a branch of the Denver and Rio Grande Narrow-gauge Railway at Cañon City, near the mouth of the main cañon of the Arkansas River. The pass discovered by Lieutenant Marshall, to the head of the Lake Fork of the Gunnison, or passing by the head of the main fork of Puncho Creek, leads up the above-named creek from the point at which it is joined by the road in question.

The impressions left upon my mind as to the general resources of Southwestern Colorado, as yet mostly in prospective, have been extremely favorable. Better communication, more settlers, and money for the development of its mines, are the needs of the present state of settlement; certainly, nature has kindly supplied the earth with much that energetic industry can subjugate to the wants of man.

The expedition of 1875 has been divided into two sections, known as the California or Pacific-coast section, and the Colorado or Rocky Range section. Lieut. Wm. L. Marshall, Corps of Engineers, has

command of the latter, which is subdivided into three parties. This section of the expedition will disband at Fort Lyon, Colo., and during the season will conclude triangulation-work left incomplete because of the uncertainty of making the best selection of the vertices of a system of triangles in a section of country thickly studded with mountain-peaks, over which no prior reconnaissance has been made, experienced during the last as well as in preceding seasons.

Lieutenant Morrison and party are instructed to fill in a space left blank in the southwestern portion of sheet 69, and search further for a line for a wagon-route leading from the valley of the Arkansas to the headwaters of the Puerco of the West, and thence branching to Northern and Eastern Arizona in the vicinity of Prescott and Camp Apache, most of which has already been determined by officers sent out from the headquarters of the Department of the Missouri, and by parties of this survey.

Detailed work extending eastward to the central line of sheet 78 will be carried as far to the south as the time and force will permit.

This section, an expedition by itself, is most completely equipped, and good work, and a great deal of it, is expected to result.

The California section has been subdivided into five parties. Detailed operations will be completed as far as practicable in sheets 72 and 73. A belt of triangles will be carried along the peaks of the coast and Sierra Nevada ranges as far north and eastward as Death Valley; portions of the outlying basins and their surrounding mountains in the vicinage will be worked up in detail by another party.

The special party under Lieutenant Bergland will examine the Colorado River, making special preliminary surveys at the following points: 1st, foot of Virgin Cañon; 2d, mouth of Rio Virgen; 3d, mouth of Vegas Wash; 4th, near Cottonwood Island; 5th, Camp Mohave; 6th, in the vicinity of the "Needles."

The flow of the river and the character of its sediments will be determined at the mouth of the Rio Virgen and at Camp Mohave. The character of the soil in the vicinity of the above-named places, and along the routes to and from their field of labor, will be carefully noted.

An approximate estimate of the cost of a canal leading from any of the above points, if one feasible can be found, with the preliminary location of its line, will be made. The above are a number of the subjects from which results are expected to be obtained during the short field-season that they will be required to labor in that hot and now comparatively desert region.

This special survey, if carried forward to completion, implies other examinations than those necessary to prove its practicability as an engineering problem, and involving detailed investigations into the present physical condition, the climatic, and other oscillations, with attendant hygrometric and surface changes in this great area of drainage; and, in view of the limited means available, no more than a preliminary examination, arranging in skeleton the accumulation of existing facts, and those made known by the labors of this season, can be expected.

A report of their results will be communicated at an early day, after their return from the field, October 15, and also a detailed estimate of the time and means necessary to determine with certainty the possibility of the diversion of the Colorado for purposes of irrigation at any point along its present channel between the foot of the Grand Cañon and its entrance into Mexican territory at the boundary, below Fort Yuma, Cal.; it having been demonstrated by results already obtained that such

diversion cannot be made between the foot of the lower Grand Cañon and the junction of its confluents, the Green and Grand Rivers.

I most respectfully suggest the desirability of entering such portions of the following areas for the season of 1876 as shall seem most practicable at the time that detailed projects shall be required to be submitted: For the Pacific coast section of the survey, the unfinished portions of sheets Nos. 72 and 73; No. 80, 64 (C), 64 (D), 48 (C), 48 (D); for the Rocky Range section, the unfinished parts of Nos. 77 and 78; also portions of 84 (B), and 85 (A), 53 (A), 52 (A), (B), 52 (C), 51 (B), 51 (D), 24 (C), 24 (D), 33, 34, 35 (A), 35 (C), 42 (A), 42 (B), 43 (A), 43 (B), 44 (A), 44 (C).

These areas, one and all, are easily connected with initial points already established, and represent sections into which mineral and other industries are most rapidly entering.

PROGRESS-MAP.

This map, skeleton in its character, and of approximate accuracy only as to its several lines and positions, has been revised to date.

There is not claimed for this map the novelty and thoroughness of a compilation, as it is simply a reduction, to which has been added a little new material, drawn principally from this survey, of what is known as the Western Territory Map of the Engineer Department, originally compiled under the direction of Lieut. G. K. Warren, Topographical Engineers, in the years 1854–'58. The skeleton-map, a reduction also from the Western Territory Map, prepared to accompany the Progress Report of 1872, was constructed in great haste, to meet any call that might be made for preliminary information, as further appropriations had been asked. It was perfected, primarily, to show the scheme proposed for a series of topographical atlas-maps of the area west of the one-hundredth meridian, and the progress of that work, to include the area entered during the season of 1872. Having answered most of the purposes for which it was intended, it was replaced by the present "Progress Map," more complete in all its characteristics.

So far as information can be obtained, the extensions of railroad and telegraph lines are represented; but as no Department of the Government is the custodian of fully reliable information upon this subject, the information has, per force, been sought from various sources; hence an uncertainty as to its completeness.

NOTE.—The designations (A), (B), (C), and (D), respectively, have been given to the northwest, northeast, southwest, and southeast quarters of each atlas-sheet, as shown upon rectangles 52, 61, 69, 77, 78, 72, and 73 of the progress-map.

ROUTES AND PROFILES.

In response to a letter from the commanding officer of Fort Cameron, Utah, to Bvt. Maj. Gen. E. O. C. Ord, while in command of the Department of the Platte, by whom it was referred, through the Chief of Engineers, to this office, a report was made upon the different routes discovered from the vicinity of Fort Cameron, Utah, to the southward, crossing the Colorado River and ending at Prescott, Ariz.

That report is not now available; but the tables of distances from Beaver, lying to the westward of Fort Cameron and Salt Lake, via several routes, all ending at Prescott, are herewith.

From Beaver, Utah, to Prescott, Ariz., (atlas-sheets Nos.* 59, 66, 67, 75,) *via Saint George Grand Wash, and Truxton Springs.*

	Distance in miles.	Total distances.		Altitude in feet above sea-level.	Remarks.	Authority.
From Beaver	......	......	391.39	6057.7	....	
To Buckhorn Springs	21.00	21.00	370.39	......	....	
To Paragoonah	9.00	30.00	361.39	6222.7	Good water, grass, and wood	Klett.
To Parowan	4.00	34.00	357.39	5910.0	Good water; grass scarce; wood plenty.	Do.
To Summit	7.50	41.50	349.89	......	Grass and water scarce; wood plenty.	Do.
To Cedar City	14.50	56.00	335.39	5726.0	Good water; no grass in vicinity; wood.	Do.
To Kanara	15.50	71.50	319.89	5419.0	Good water, grass, and wood	Do.
To Belleview	17.00	88.50	302.89	......	......do	Do.
To Toquerville	8.00	96.50	294.89	......	......do	Do.
To Harrisburg	7.70	104.20	287.19	......	......do	Do.
To Washington	9.00	113.20	278.19	2906.0	......do	Do.
To Saint George	4.80	118.00	273.39	......	......do	Do.
To Camp at head of Grand Wash.	24.65	142.65	248.74	......	Black Rock Springs, west-north-west of camp; water, except in dry seasons; grass and wood.	Do.
To Washi-Pahghun Springs.	17.37	160.02	231.37	4421.0	Good water, grass, and wood	Do.
To Pahghun-Pahghun Springs.	22.79	182.81	208.58	2281.9	Good water; grass; no wood	Do.
To Colorado crossing of expedition of 1871.	25.28	208.09	183.30	......	Grass on mesa; driftwood only; no ferry; river believed to be unfordable, unless during October and November of exceptional years.	Do.

* The center of the public square in the town of Beaver is approximately two and one-half miles by wagon-road from Fort Cameron, and nearly due west.

From Beaver to Paragoonah, road good, Mormon settlement.
to Parowan, Summit, and Cedar City, road good; latter places Mormon settlements.
to between Belleview and Toquerville, road becomes very steep in places.
to between Toquerville and Saint George, road sandy; Mormon settlements along road.

From Saint George to the Colorado crossing, trail practicable for wagon-road, except at Cottonwood Springs, (twelve miles north of Colorado River,) where it leaves the Dry Wash and climbs steep mesas. At this point road would have to be built.

From crossing to Truxton Springs, road could be built without difficulty, though in places grade would be steep.

From Truxton Springs to Prescott, good wagon-road; joins Prescott and Hardyville mail-road at Cottonwoods, near old Camp Willow Grove.

From Beaver, Utah, to Prescott, Ariz., (atlas-sheets Nos. 59, 66, 67, 75,) via Saint George, Grand Wash, and Truxton Springs.

	Distance in miles.	Total distances.		Altitude in feet above sea-level.	Remarks.	Authority.
From Beaver	......	......	......	6057.7	....	
To Colorado crossing	208.09	208.09	183.30	......	Wood; water of river muddy; grass at river scarce.	Nell.
To Tinnahkah Springs.	21.88	229.97	161.42	4080.0	Small springs; bunch-grass; wood.	Do.
To Attoovah (or Cañon) Springs.	14.21	244.18	147.21	......	Spring in cañon; bunch-grass; cedar-trees.	Do.
To New Creek of Ives, or Pahroach Springs.	14.24	258.42	132.97	......	Good camping-grounds; plenty wood, water, and grass.	Do.
To Truxton Springs	16.91	275.33	116.06	3885.5	Bunch-grass through sage-brush, water, and wood.	Do.
To old Camp Willow Grove.	25.00	300.33	91.06	......	Wood, water, and grass	Klett.
To Fort Rock	15.00	315.33	76.06	......	Good water; no grass; little wood.	Do.
To Oaks and Willows	27.13	342.26	67.06	......	Water, wood, and grass	Do.
To old Camp Hualapais.	9.00	351.46	39.93	5321.9	Good water and grass; plenty wood.	Do.
To toll-gate in Williamson's Valley.	16.56	368.02	23.37	......	Water and wood; little grass	Do.
To Prescott	23.37	391.39	0.00 From	5318.0	Water and grass	Do.

Good camping-grounds at crossing of Muddy Cañon, between Fort Rock and Oaks and Willows.

From Beaver, Utah, to Prescott, Ariz., (atlas-sheets Nos. 59, 66, 67, 74, 75,) Saint George mouth of Virgin and Beale's Springs.

	Distance in miles.	Total distances.		Altitude in feet above sea-level.	Remarks.	Authority.
From Beaver	......	......	429.98	6057.7	....	
To Saint George	118.00	118.00	310.98	....	....	
To Beaver-dam	30.90	148.90	281.08	....	Water alkaline; grass scarce; wood plenty.	Klett.
To Saint Thomas	50.00	198.90	231.08	1600.0	Good water; grass and wood scarce.	Do.
To Mouth of Rio Virgen	24.56	223.46	206.52	....	Water muddy and alkaline; no grass; willows; ferry.	Do.
To Mountain Spring	41.43	264.89	165.09	5500.8	Water alkaline; little bunch-grass; wood.	Do.
To Chloride City	14.53	279.42	150.56	....	Water brackish; little grass	Do.
To Mineral Park	7.00	286.42	143.56	....	Water alkaline; wood and grass at small distance from town.	Do.
To Cerbat	6.00	292.42	137.56	....	Water and wood; very little grass.	Do.
To Beale's Springs	9.00	301.42	128.56	....	Water and wood; grass some distance from camp.	Do.
To Hualapais Springs	16.65	318.07	111.91	....	Good water, wood, and grass	Do.
To old Camp Willow Grove.	20.85	338.92	91.06	*4170.0	......do	Do.
To Fort Rock	15.00	353.92	76.06	....	Good water; no grass; little wood	Do.
To Camp Hualapais	36.13	390.05	39.93	5321.9	Good water, wood, and grass	Do.
To toll-gate	16.56	406.61	23.37	....	Good water and wood; little grass	Do.
To Prescott	23.37	429.98	0.00	5318.0	Good water and grass	Do.

* Cottonwood.

Road from Saint George to Beaver-dam, across the ranges, good and hard; plenty of wood.

Road from Beaver-dam to Saint Thomas, along and through the Virgin River bed, quicksand in places.

Road from Saint Thomas to mouth of Virgin River good; ferry across Colorado one-fourth mile below mouth.

Road from Virgin to Mountain Spring generally good.

Road from Mineral Park good; mining-town.
Road from Cerbat sandy; mining-camp.
Road from Beale's Spring good; abandoned military post.
Road from Cottonwoods good.
From Fort Rock to Prescott. Mineral Park and Cerbat are both situated about one mile east of road from Chloride City to Beale's Spring.

From Beaver, Utah, to Prescott, Ariz., (atlas-sheets Nos. 59, 67, 75,) via mouth of Paria Creek

	Distance in miles.	Total distances.		Altitude in feet above sea-level.	Remarks.	Authority.
From Beaver	......	......	446. 04	6057. 7		
To Fremont Pass	6. 00	6. 00	440. 04	... .	Single spring; plenty wood; grass poor.	Weyss.
To Panquitch	26. 00	32. 00	414. 04	6273. 3	Water and wood; grass poor.	Do.
To Azay's Ranch	19. 50	51. 50	394. 54	....	......do	Do.
To forks of river	7. 60	59. 10	386. 94	....	Grass, wood, and water.	Do.
To Johnson's Springs	31. 00	90. 10	355. 94	....	Good water, wood, and poor grass.	Do.
To Navajo Wells	14. 00	104. 10	341. 94	....	Animals watered with bucket; wood; grass scanty.	Thompson.
To House-rock Springs	27. 70	133. 80	312. 24	....	Wood and grass; spring off from road, at foot of cliff.	Do.
To Jacob's Pool	14. 10	147. 90	298. 14	....	Spring at ranch; wood scarce.	Do.
To Soap Springs	13. 00	160. 90	285. 14	....	Water alkaline; wood scarce; grazing near cañon.	Do.
To mouth of Paria	15. 20	176. 10	269 94	*3294. 0	Drift-wood; poor grass; ferry.	Do.
To Navajo Springs	7. 75	183. 85	262. 19	....	Excellent water and grass; wood on mesas.	Do.
To Limestone Water-pockets.	17. 73	201. 58	244. 46	5405. 4	Water in pools to right of road, in small gulch; grass; little wood.	Do.
To Water-pockets	28. 62	230. 20	215. 84	....	Springs in pockets; grass and wood scarce.	Do.
To Moquis-Pueblo trail.	4. 25	234. 45	211. 59	....	Wood, water, and grass in vicinity, north of road.	Do.

* Two miles above mouth of Paria.

Road from Beaver to Fremont Pass good; near Panquitch settlement difficult on account of water-ditches.
From Beaver to Navajo Wells, road good, except in wet weather, when it becomes very bad; grass along road very scant, and insufficient to decently support animals on the march.
From Navajo Wells to Ferry-landing, road is good till it passes over Kaibab Plateau, where it becomes rough.
To Jacob's Pool, road sandy in places; good to mouth of Paria, but crosses a number of arroyos.
To Navajo Springs, good made road round springs; excellent to Limestone Pockets and beyond, till it passes divide, when it becomes sandy.
From Navajo Springs to Moquis-Pueblo trail, good road, following arroyo.

From Beaver, Utah, to Prescott, Ariz., (atlas-sheets Nos. 59, 67, 75,) *via mouth of Paria Creek.*

	Distance in miles.	Total distances.		Altitude in feet above sea-level.	Remarks.	Authority.
From Beaver	......	......	......	6057.7	......	
To Moquis-Pueblo trail	0.00	234.45	211.59	......	......	
To Moen-copie Creek	11.00	245.45	200.59	4984.1	From map; distance probably too small.	
To Colorado Chiquito	12.00	257.45	188.59	......	......do	
To Cascades	58.75	316.20	129.84	......	From map; water alkaline: wood; grass scarce on lava *débris* a few miles south of river.	Somers.
To wagon-road	11.50	327.70	118.34	......	Plenty of wood and grass	Do.
To Cosnino tanks	4.00	331.70	114.34	6244.1	Wood and excellent grass; water said to exist in tanks all the year.	Do.
To Antelope Springs	24.00	355.70	90.34	8065.1	Good grass and wood anywhere	Nell.
To Volunteer Spring	11.20	366.90	79.14	7106.4	Good wood, water, and grass	Do.
To spring south of Bill Williams Mountain.	27.32	394.22	51.82	5520.6	......do	Do.
To Rattlesnake Cañon	15.42	409.64	36.40	4600.0	Wood scarce; good water; bunch-grass.	Do.
To Postal's Ranch	14.40	424.04	22.00	......	Good water; wood and grass poor.	Do.
To Prescott	22.00	446.04	......	5318.0	Plenty water and wood	Do.

From Moquis-Pueblo trail to Cascades and from Cosnino tanks, distances were taken from map, and for road distances (though correction was made) are probably too small.

The trail used from Cascades on Colorado Chiquito to wagon-road is perfectly practicable for wagon; hence good mail-road to Prescott.

From Salt Lake to Panquitch, (atlas-sheets Nos. 50, *and* 59.)

	Distance in miles.	Total distances.		Altitude in feet above sea-level.	Remarks.	Authority.
From Salt Lake	......	......	259.55	......	......	
To Mountain House	21.00	0.00	238.55	......	......	Thompson.
To Provo	24.00	45.00	214.55	4534.5	Camp 4, 4 miles south of Provo	Do.
To Spanish Fork	13.40	58.40	201.15	......	......	Do.
To Santaquin	12.60	71.00	188.55	*4523.0	......	Do.
To Mona	11.50	82.50	177.05	......	......	Klett.
To Nephi	9.00	91.50	168.05	4920.0	......	Do.
To Chicken Creek	13.50	105.00	154.55	......	......	Do.
To Sevier bridge and bend of Sevier.	21.25	126.25	133.30	4765.0	......	Do.
To Gunnison	14.00	140.25	119.30	5144.6	......	Do.
To Salina	16.90	157.15	102.40	......	......	Do.
To opposite Glenwood	15.00	172.15	87.40	†5282.6	......	Do.
To Monroe	19.00	191.15	68.40	......	......	Do.
To Marysvale	14.00	205.15	54.40	......	......	Do.
To Circleville	25.00	230.15	29.40	5624.0	......	Thompson.
To Panquitch	29.40	259.55	0.00	6273.3	......	Do.

* Payson. † Richfield.

Utah Southern Railroad, from Salt Lake, through Provo, nearly to Santaquin. From Santaquin to Panquitch good wagon-road, with wood, water, and grass. From Chicken settlement, road to Gunnison runs through Salt Creek settlement, slightly shortening the above given distance.

From Salt Lake City to Panquitch, 259.55 miles.

From Salt Lake City to Beaver, (atlas-sheets Nos. 50 *and* 59,) *via Fillmore.*

	Distance in miles	Total distances.		Altitude in feet above sea-level.	Remarks.	Authority.
From Salt Lake City	......	......	217.60	....	....	
To Santaquin	71.00	......	146.60	....	Utah Southern railroad	Thompson.
To Mona	11.50	82.50	135.10	....	....	Do.
To Nephi	9.00	91.50	126.10	4920.0	....	Klett.
To Chicken Creek	13.50	105.00	112.60	....	....	Do.
To Scipio	22.30	127.30	90.30	5113.0	....	Do.
To Holden	14.00	141.30	76.30	....	....	Thompson.
To Fillmore	9.10	150.40	67.20	6025.0	....	Do.
To Meadow Creek	10.80	161.20	56.40	....	....	Do.
To Corn Creek	6.90	168.10	49.50	5992.0	....	Do.
To Cove Creek	22.10	190.20	27.40	6959.0	....	Do.
To Pine Creek	6.60	196.80	20.80	....	....	Do.
To Indian Creek	12.20	209.00	8.60	....	....	Do.
To Beaver	8.60	217.60	0.00	6057.8	....	Do.

From Chicken Creek good stage-road, crossing Sevier by bridge, 21.25 miles from Chicken Creek.

	Miles.
Shortest line from Beaver to Prescott (air-line)	256.00
Via mouth of Virgin	429.98
Via mouth of Paria	446.04
Via Grand Wash and Colorado crossing of 1871	391.39

Conjectural route *via* Pahroach Springs shortens distance to Prescott by about seventeen miles.

Conjectural route, believed to be practicable, from mouth of Moen-copie to Sniveley's Holes, shortens distance by approximatively fifty-nine miles; making distance from Beaver via mouth of Paria 388.03 miles. No water known to exist between the Colorado Chiquito and Crater Lake.

	Miles.
From Salt Lake City to Prescott, via Utah Southern Railroad, to Santaquin, Panquitch, mouth of Paria, and Cascades	705.50
Via Beaver and mouth of Virgin	647.58
Via conjectural lines from Moen-copie via Crater Lake	648.00

It appears that the shortest possible distance in an air-line from Beaver to Prescott is 256 miles; that via the mouth of the Virgin River, Sacramento Valley, Beale's Springs, &c., (entirely a wagon-road,) the distance is 429.98 miles. From the same point to Prescott, via the head of the Sevier, the mouth of Paria Creek, Little Colorado River, &c., (wagon-road except for a short distance in the immediate vicinity of the Little Colorado,) the distance is 446.04 miles. By way of Saint George, Utah, the Grand Wash, Colorado crossing of the expedition of 1871, (wagon road to the Colorado River and from Truxton Springs,) the distance is 391.39 miles, which is shortened by a conjectural road via the edges of the Colorado plateau and Pahroach Springs by seventeen miles. The route via the mouth of the Paria and that via the mouth of the Virgin River could, at the present writing, be made available by small bodies of troops moving with wagon-transportation; the more easterly one being preferable, principally because of several long marches over sandy ground, with long intervals either destitute or affording an insufficient amount of water at certain points that occur on the other.

By ascending the Little Colorado from a point at which it is reached by the Mormon wagon-road from the mouth of the Paria, to Sunset crossing, where the regularly-traveled road westward across the San Francisco plateau leaves that stream, it becomes practicable for military commands, say by companies well-equipped and carrying a few days'

From Beaver, Utah, to Prescott, Ariz., (atlas-sheets Nos. 59, 66, 67, 75,) via Saint George Grand Wash, and Truxton Springs.*

	Distance in miles.	Total distances.		Altitude in feet above sea-level.	Remarks.	Authority.
From Beaver	......	......	391. 39	6057. 7	......	
To Buckhorn Springs	21. 00	21. 00	370. 39	......	......	
To Paragoonah	9. 00	30. 00	361. 39	6222. 7	Good water, grass, and wood	Klett.
To Parowan	4. 00	34. 00	357. 39	5910. 0	Good water; grass scarce; wood plenty.	Do.
To Summit	7. 50	41. 50	349. 89	......	Grass and water scarce; wood plenty.	Do.
To Cedar City	14. 50	56. 00	335. 39	5726. 0	Good water; no grass in vicinity; wood.	Do.
To Kanara	15. 50	71. 50	319. 89	5419. 0	Good water, grass, and wood	Do.
To Belleview	17. 00	88. 50	302. 89	......	......do	Do.
To Toquerville	8. 00	96. 50	294. 89	......	......do	Do.
To Harrisburg	7. 70	104. 20	287. 19	......	......do	Do.
To Washington	9. 00	113. 20	278. 19	2906. 0	......do	Do.
To Saint George	4. 80	118. 00	273. 39	......	......do	Do.
To Camp at head of Grand Wash.	24. 65	142. 65	248. 74	......	Black Rock Springs, west-northwest of camp; water, except in dry seasons; grass and wood.	Do.
To Washi-Pahghun Springs.	17. 37	160. 02	231. 37	4421. 0	Good water, grass, and wood	Do.
To Pahghun-Pahghun Springs.	22. 79	182. 81	208. 58	2281. 9	Good water; grass; no wood	Do.
To Colorado crossing of expedition of 1871.	25. 28	208. 09	183. 30	......	Grass on mesa; driftwood only; no ferry; river believed to be unfordable, unless during October and November of exceptional years.	Do.

* The center of the public square in the town of Beaver is approximately two and one-half miles by wagon-road from Fort Cameron, and nearly due west.

From Beaver to Paragoonah, road good, Mormon settlement.
to Parowan, Summit, and Cedar City, road good; latter places Mormon settlements.
to between Belleview and Toquerville, road becomes very steep in places.
to between Toquerville and Saint George, road sandy; Mormon settlements along road.

From Saint George to the Colorado crossing, trail practicable for wagon-road, except at Cottonwood Springs, (twelve miles north of Colorado River,) where it leaves the Dry Wash and climbs steep mesas. At this point road would have to be built.

From crossing to Truxton Springs, road could be built without difficulty, though in places grade would be steep.

From Truxton Springs to Prescott, good wagon-road; joins Prescott and Hardyville mail-road at Cottonwoods, near old Camp Willow Grove.

METEOROLOGICAL AND HYPSOMETRICAL.

Operations in this branch of the survey were conducted under the superintendence of the chiefs of parties, by a body of observers who had been carefully instructed in the details of observation as prepared for the work, and based upon the results of years of experience and care.

Observations were taken, as usual, with a view to the compilation of altitudes, and a knowledge of the general climatic features of the regions traversed.

Each party was provided with complete sets of instruments, including mercurial cistern-barometers, aneroid barometers, with attached thermometers, and hygrometers, and with means for cleaning and repairing, when necessary, the cistern-barometers.

Besides instrumental observations, the amount of cloudiness, character and motion of clouds, the direction and estimated velocity of the wind, fall of rain and dew, and other phenomena pertaining to this field of inquiry, were carefully observed and recorded.

Observations on the cistern-barometer and hygrometer were taken at five hundred and seventy-two of the most important points along the routes, the number of observations at each point ranging from three to thirty-five, and aneroid and thermometer readings were taken at three thousand three hundred and thirty-five minor topographical stations, which, checked as they have been by comparisons with a cistern-barometer before leaving camp in the morning and immediately upon reaching camp in the evening, may be regarded as sufficient data from which to compute a reliable series of altitudes.

Lieutenant Marshall submits a special report (see Appendix F) upon the barometric work of the season, with a description of the system of observation, record, and reduction in present use upon the survey.

Much credit is due to Lieutenants R. L. Hoxie and Wm. L. Marshall, Corps of Engineers, for the furtherance of the systematic organization of this branch of the work.

NATURAL HISTORY.

Results growing out of inquiries in the subjects of geology, paleontology, mineralogy, including chemical analysis of minerals, mineral waters, soils, plants, &c., zoology, and botany, and reports thereon by individuals selected for the purpose, are all more or less calculated to increase our knowledge of the recent and extinct fauna and flora of the regions traversed, and, so far as compatible with the main object of the survey, to wit, the preparation of detailed topographical maps and an examination into the general resources of the region surveyed, these cognate scientific branches have each their representative or representatives.

GEOLOGY AND PALEONTOLOGY.

Active geological operations were not prosecuted during the year, excepting by Prof. E. D. Cope, as incidental to his paleontological researches in Northern New Mexico, and by Dr. O. Loew, as bearing upon the chemical and mineralogical investigations made by him in Northern New Mexico and Southern Colorado.

A report by Professor Cope (Appendix G 1) gives the results of his geological work for the season; also one by Dr. Loew, of the same character. (See Appendix G 2.)

Professor Cope was fortunate in finding prolific fossil beds, especially of

vertebrates, in the Eocene of the Gallinas group in New Mexico; and a preliminary report of his results in this interesting field was submitted with the last annual report; subsequently a special publication was made upon the *Vertebrata* of the Eocene of Northern New Mexico. His report, nearly complete, upon the *Vertebrata* collected under his direction, and their relations with plates of new species, has been submitted, and will form a part of volume IV, (Paleontology.)

Dr. Loew has submitted during the year a report upon the composition of a number of mineral and hot springs in Southern Colorado and Northern New Mexico, embracing those of Manitou, Red Creek, and Pagosa, Colo., and Las Vegas and Abiquiu, N. Mex., which has been included in volume III, (Geology.)

Dr. C. A. White, of Bowdoin College, Brunswick, Me., has been engaged for the major part of the year in the identification of the species of invertebrate fossils collected in the seasons of 1871, 1872, and 1873. A preliminary report of his labors, giving descriptions of new species, was published in octavo form. His finished report has been received, and will be Part I of volume IV, (Paleontology.)

The number of species new to science was found to be fifty, and the report based upon material drawn from a field of extended and varying geographical distinctions has been made complete and comprehensive.

The services of Dr. Oscar Loew have been retained for the expedition of 1875, and he wlll accompany the party to the Colorado River; and the veteran geologist, Jules Marcou, joined the California section of the expedition at Los Angeles, Cal., where twenty-two years before he had passed while holding the appointment of geologist to the expedition under the command of Lieut. A. W. Whipple, Corps of Topographical Engineers, for a survey for a railroad route along the thirty-fifth parallel. He will be assisted by Douglas A. Joy, a young graduate of the School of Mines, Columbia College, New York.

Mr. A. R. Conkling, a graduate of several years' standing from the Sheffield Scientific School of Yale College, accompanies party No. 3 of the Colorado section of the expedition, and will examine the mountain structure from the Spanish Peaks southward to the head of the Pecos.

The appropriation for the coming fiscal year having been much reduced, the services of the several geological assistants will necessarily be temporary, unless the funds available after the assembling of Congress can be made adequate to the more vigorous prosecution of this adjunct of the survey.

The manuscript for volume III (Geology) was ready for the press early in the year; but owing to a defect in the law making appropriation for publication, the printing could not go forward until the defect was remedied. The proof is now being received. Proofs of four of the geological sheets to accompany the volume have been received, and four more are ready for, and are soon to be in the hands of, the engraver.

MINERALOGY.

Dr. Loew submits an interesting report (see Appendix G 2) on the mineralogical features observed by him in New Mexico and Colorado, including tables of analyses of minerals, mineral waters, &c., to which are added notes and tables on climatology, temperature of rivers, creeks, and springs encountered.

One hundred and sixty-five mining-districts have been examined by the officers and assistants of the survey during the past four years, with a view to obtaining specific information in regard thereto, particularly

as to discovery, time worked, distance from railroad communication, boundaries, area of mineral-croppings, position of ledges in relation to main range, directions of lodes and deposits, character of wall-rock, nature of ores, results of assays, annual production, number of mills, cost of mining, milling, labor, supplies, &c.

Most of the information gathered has been collated, and will appear in volume I of the Survey Reports.

ECONOMIC BOTANY AND AGRICULTURE.

The agricultural resources of the Far West is a question increasing in interest with each succeeding year, and is one of vital importance to the Government and country at large.

While the main objects of the survey do not admit of elaborate investigations upon this and other subjects of general interest, it has nevertheless been attempted to push inquiry as far as time and facilities would allow. Accordingly, Doctors Rothrock and Loew submit reports (see Appendixes H 1 and H 2) upon the subject; the former in a relative way in connection with his more specific field, (botany,) adverting to the general topography of the region traversed, its climatology, the relation of forest plants and timber to present and prospective wants, the probable increase in agricultural areas under cultivation and irrigation, and a system of tree-culture, the sanitary conditions of the country as influencing immigration, &c.

Dr. Loew treats more especially of the capacities of the soil, its constituent elements, the character and influence of climate, irrigation, &c., with analyses and comparative tables. He also treats upon this subject incidentally in his report upon mineralogy, (see Appendix G 2.)

ZOOLOGY AND BOTANY.

Collections in these branches have been made during the year by Acting Assistant Surgeons H. C. Yarrow and J. T. Rothrock, United States Army, and H. W. Henshaw and Charles E. Aiken, ornithologists. Dr. Yarrow submits a general itinerary, and Assistants Henshaw and Aiken report upon the collections in ornithology. An "Annotated List of the Birds of Arizona," by Mr. H. W. Henshaw, is introduced, (see Appendixes I 1 and I 2.)

With small additional expense no little increase has been made in the lots of collections, heretofore large, that have been gathered from year to year.

ETHNOLOGY, PHILOLOGY, AND RUINS.

Ethnological material characteristic of present and extinct tribes has been gathered, and facts of note recorded by several members of the expedition since the season of 1872. Relics of stone, flint, &c., have, during the present season, been discovered along the coast near Santa Barbara that rival all others yet found by parties of the survey.

A party in charge of Acting Assistant Surgeon H. C. Yarrow, United States Army, assisted by Acting Assistant Surgeon J. T. Rothrock, United States Army, H. W. Henshaw, and several laborers, has been engaged for some weeks in their excavation.

Selections from the multitude of specimens will be forwarded to Washington; meanwhile information of shell-mounds and other indications of ancient buried remains of a people of which history contributes no trace

reaches us from several points, thus affording fresh fields for further search.

Many crania were exhumed, not only in this locality, but also in New Mexico, in the season of 1874.

Vocabularies have been obtained from several of the nomadic and pueblo tribes in Colorado and New Mexico by members of the expedition, over whose names they will be published.

Interesting relations, not heretofore supposed to exist, have been adduced from a study of these vocabularies, by Professor Gatschet, whose report is herewith, compiled principally from data and vocabularies collected by Dr. O. Loew, of the survey, in addition to his regular duties, and who has never lost an opportunity to push investigation in this direction, (see Appendix J 4.)

The ruins newly discovered, and those known heretofore to exist, that have been encountered by the parties, have been located so that a special map may be prepared upon which to delineate their geographical relations.

Professor Cope submits a report "On the Remains of Population observed on and near the Eocene Plateau of Northwestern New Mexico," (see Appendix J 1,) in which he reaches the conclusion that the country of the Gallinas, and the Eocene plateau to the west of it, were once occupied by a numerous population, indicated by ruined buildings, pottery, flint implements, and human bones.

Descriptions and diagrams of ruined buildings are given, the age of some of which he places at three hundred and thirty-five years. This "Sketch of a glimpse at one locality of the earliest civilization known on the American Continent" will be found of value to the student of history and archæology.

Dr. Loew and Lieutenant Birnie submit reports on the ruins visited by them in New Mexico, which will be found of interest to many readers, (see Appendixes J 2 and J 3.)

Dr. Yarrow, in his report, (see Appendix I 1,) also submits some interesting statements in regard to the pueblo of Taos, N. Mex., the character, forms of government, habitations, &c., of its people. These subjects are of increasing interest, as they are more and more examined and understood, particularly in connection with the study of the ancient peoples of these regions.

The material gathered will be grouped in a systematic form, and with map and other illustrations, such as photographs of the aborigines, their habitations, implements, (domestic and warlike,) apparel, &c., has been considered as an appropriate subject for another quarto volume, to be numbered seven, and added to the series of quarto reports.

PUBLICATIONS.

The maps and reports published during the year, with suggestions as to further publications and an estimate of their cost, appear in Appendix K.

Of the six volumes to be published in accordance with the act of June 23, 1874, amended by the act approved February 15, 1875, two (Geology and Zoology) are at the rendering of this report in the hands of the printer. Two others will, it is hoped, reach completion early within the ensuing fiscal year. The independent publications proposed during the coming fiscal year are, "Catalogue of Mean Declinations" and "Tables of Geographical Positions, Altitudes, &c."

PHOTOGRAPHS.

As usual, a photographer, in the person of Mr. T. H. O'Sullivan, who has accompanied the expedition for the third season, has been added to one of the parties, and the stock of negatives has been increased by other characteristic views of scenery, ruins, and groups of Indians. During the year a few selected sets of landscape and stereoscopic views have been printed under the approval of the honorable Secretary of War; only sufficient in number, however, for the use of the War Department, the Engineer Bureau, and this office.

CONCLUSION.

In the conclusion of my last annual report (see Appendix FF of the Annual Report of the Chief of Engineers for 1874) attention was invited to the necessity for the continuance of the survey and to some of the useful applications of its results.

While continued at its present size and stage of development, it is perhaps unnecessary to set forth other advantages that permanently ensue from the aggregation and dissemination by Government and other publications of exact geographical knowledge of any portion of the country, only meager parts of which as yet have been mapped with even tolerable accuracy; yet it may not be inappropriate to state that the manuscript and published map results of the survey, which, since its organization, has been so directed as to embrace large areas of political divisions, the importance of which is increasing, will prove a substantial contribution to a general topographical map of the whole country.

Information concerning new routes of travel throughout the areas traversed, with suggestions as to the opening of Government wagon-roads, and the probable routes for future railway communications, &c., together with lists of camps, distances, geographical positions, altitudes, &c., over present lines of supply, are all of valuable assistance to the Government in looking to a decrease of expenditure in the maintenance and supply of establishments in the territory of its wards, and add to the practical features of a work, which, although it might with undoubted advantage be continued vigorously until detailed topographical maps of the entire interior shall result, equal to those produced by the great trigonometrical and topographical surveys of foreign powers, yet, inasmuch as the preservation of public utility lies at the foundation of duty in all Government undertakings, questions born of a desire to economize expenditures must needs be met and answered.

It will be attempted from time to time, in a general manner and finally by statistics, to show that the money expended for refined geographical surveys is warranted by the economic value of the information gained for the use of the War Department, *alone*, in directing its operations, and that the indirect values of the maps and reports to the other Departments of the Government, and to the country at large, are attained at no cost to the public purse.

The act appropriating for the continuance of the survey admitting of the prosecution with the present force in any part of the United States west of the hundredth meridian, the area selected for the season was suggested in the project submitted under your direction, which was approved by yourself and by the honorable Secretary of War.

In future, sections lying adjacent to the Mexican border should be entered in winter and early spring. No parties have been so far placed

in the field during these seasons because of the uncertainty of continued appropriations; and as it will result economically to have winter as well as summer campaigns, it is to be hoped that the action of Congress, if favorable to the continuance of the survey, will place it upon a more permanent basis, so that the officer in charge can look forward with a degree of certainty to a practicable appropriation upon which recommendations for the disposition of the field-parties can be based sufficiently in advance to admit of their reaching in due season sections north or south between the forty-ninth parallel and the Mexican boundary.

It is believed that during the year an advantageous interchange of results with the General Land-Office has been had.

During the present season, connection has been made with the main triangulation stations of the United States Coast Survey in the vicinity of Los Angeles, Cal.; and the belt of triangles observed, if the several assistants are fully successful, will reach as far to the eastward as Death Valley in Eastern California.

ESTIMATES.

For continuing the field and office work of the survey, an appropriation of $95,000 will be required.

The probable distribution of expenditures under this appropriation would be as follows:

For parties in the field	$40,000 00
For office-parties	13,920 00
For transportation, including purchase of animals	12,000 00
For material and outfits	6,500 00
For subsistence of parties in the field	6,000 00
For forage, winter-herding, fuel, storage, &c	9,500 00
For repair of instruments	1,500 00
For contingencies, including erection of observatories and monuments at astronomical and geodetic stations, and office-expenses not otherwise estimated for	5,580 00
Total	95,000 00
Amount appropriated to continue geographical surveys of the territory of the United States west of the one hundredth meridian, for the fiscal year ending June 30, 1876	40,000 00
Amount remaining on hand at the close of the fiscal year ending June 30, 1875	24,697 60
Amount required for field and office work for fiscal year ending June 30, 1877	95,000 00
Amount appropriated for engraving and printing the plates and atlas-sheets accompanying the reports of geographical surveys west of the one hundredth meridian, for the fiscal year ending June 30, 1876	20,000 00
Amount remaining on hand at the close of the fiscal year ending June 30, 1875	22,882 70
Amount required to continue the publications for the fiscal year ending June 30, 1877, (see Appendix K.)	25,000 00

The amounts above estimated for are the least that can be employed to advantage if a vigorous prosecution of the work is expected, and hence it is submitted that the total amount should be appropriated.

All of which is respectfully submitted.

GEO. M. WHEELER,
First Lieutenant Corps of Engineers, In charge.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

SUPPLEMENTARY REPORT OF OCTOBER 1, 1875.

My own duties took me from the office in Washington on the evening of May 26, to the field, in connection with the California section, where I was engaged until September 1.

Returning, Washington was reached September 10, and office-duties resumed. While in the field, I had personal charge of one of the main field-parties of the California section, which, at the date of my leaving, was divided into two parts, one remaining in charge of Acting Assistant Surgeon J. T. Rothrock, and another in charge of Mr. Francis Klett, who has now been with the survey for the fifth year.

There were two other separate and distinct parties: the first in charge of Lieut. C. W. Whipple, Third United States Artillery, (who had meanwhile been transferred to the Ordnance Corps,) the second in charge of Lieut. Rogers Birnie, jr., Thirteenth United States Infantry. A special party under Lieut. Eric Bergland had proceeded to the Colorado River early in June, to make certain special examinations along its banks, and run a reconnaissance-line and occupy several mountain-stations *en route*.

The Colorado section was placed in charge of Lieutenant Marshall, who took the field on the 15th of June from Pueblo, in charge of one of the parties; Lieut. C. C. Morrison, Sixth United States Cavalry, and Lieut. W. L. Carpenter, Ninth United States Infantry, having been charged each with the command of one of the other parties. A special natural-history party operated distinctly from the main branch of the California section, in the immediate vicinity of Santa Barbara, Cal., co-operating with parties of the Smithsonian Institution engaged in making ethnological collections. This party was eminently successful; and the resulting collections, consisting of a large number and variety of stone implements and wares, &c., human crania and bones, are now daily expected at this office. Meanwhile the office-work has been proceeded with as rapidly as possible Mr. George M. Lockwood having been placed in charge. Three draughtsmen and one computer have been engaged in the topographical room. Duplicate field-records and plots are now transmitted to the office in Washington from month to month during the field-season.

On the 31st of August, the parties whose command I had relinquished reported from the vicinity of Kernville, Cal.

Lieutenant Birnie forwards a succinct field-report from Panamint, Cal., under date of the 27th of August. On the 24th of August, Lieutenant Whipple sent by mail a letter from old Fort Tejon, setting forth the continuance of his operations in the Coast range near Soledad Pass, at the head of Santa Clara valley. Lieutenant Bergland reported the arrival of his party at Camp Mohave, Ariz., August 23, and by telegraph at San Bernardino, Cal., September 24. Lieutenant Marshall submits reports of his own party up to August 14, at camp on the Dolores River on the west side of the San Miguel range, Colorado, with accompanying reports of Lieutenant Morrison from Fort Wingate, N. Mex., on the 27th of July, and from Lieutenant Carpenter at Fort Garland on the 1st of August. Without exception, the health of the command, consisting of 77 officers, assistants, and employés, is good. The 145 riding, pack, and team animals are reported in good condition. No casualties of any special note have occurred. The results, so far, have been quite as successful as could have been expected; and the practicability of dividing the expedition of the season into separate and distinctly-organized parties, working under independent instructions, has been proven.

The Colorado section will reach Fort Lyon, on the Arkansas River,

about November 25. The California parties will reach Caliente, the present terminus of the Southern Pacific Railroad, about the same date. They will be disbanded, the animals transferred, and the articles of public property put in store.

Special operations for the month of October.—Regular office-work will be continued as usual. The publication of volumes III and V will be pushed with all possible vigor. The manuscript for volumes II and IV will be sent to the printer as soon as he is ready for it. The manuscript of the Catalogue of Mean Declinations of about 2,000 Stars, now being prepared by Professor Safford, will be finished. Lieutenant Bergland will be directed to take a temporary office at Los Angeles, and complete observations necessary to bring about a complete connection between the base measured by this survey during the past season and that measured by the Coast Survey in 1854 near Los Angeles, and certain other observations necessary to complete belts of triangulation, which, if successfully concluded, will reach from the coast near Los Angeles, in a triple tier, northeastward to about the one hundred and sixteenth meridian of longitude west from Greenwich. These belts of triangles form the basis of a system that can be developed over at least all of the southern half of California, a portion of Southwestern Nevada, and all of Western Arizona. From the preliminary plots and field-work, profiles and other sections and special plots will be made, and a report of the examination of the Colorado River at the mouth of the Virgin, near Camp Mohave, will be prepared and forwarded to this office without delay. When Lieutenant Bergland submits this preliminary report, it can more nearly be determined as to the practicability of re-organizing his party and dispatching it to the lower part of the Colorado River, to continue its operations during the winter months, in advance of which the matter will be submitted to the Chief of Engineers for further instructions, if such be considered necessary. It is hoped that funds from the appropriation for explorations and surveys, for the present fiscal year, may be available, sufficient in amount to cover the expense of a winter campaign of about four months; if not, further appropriation must be asked.

The several parties of the California and Colorado sections will prosecute this work during the month in the areas assigned to them.

Respectfully submitted.

GEORGE M. WHEELER,
Lieutenant of Engineers, in charge.

OCTOBER 1, 1875.

APPENDIX A.

EXECUTIVE REPORT OF LIEUTENANT WILLIAM L. MARSHALL, CORPS OF ENGINEERS, ON THE OPERATIONS OF PARTY NO. 1, DIVISION 1, FIELD-SEASON OF 1874.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., April 16, 1875.

SIR: I have the honor to submit the following brief executive report of the operations of party No. 1, division No. 1, of the survey under your charge, during the field-season of 1874.

The party was organized under your immediate supervision at Pueblo, Colo., during the latter part of July, and in all numbered nine men, viz: First Lieut. W. L. Marshall, Corps of Engineers, executive officer; assistant, Louis Nell, chief of triangulation; Mr. W. R. Atkinson, assistant topographer; Mr. Bernard Gilpin, meteorologist; Mr. T. R. Davis, odometer and aneroid recorder; three packers; and one cook.

While at Pueblo, the party assisted in the measurement of the base and the development to the mountains of the initial triangles.

On August 1, the work upon the base having been completed, we proceeded via the Puncho Pass and Cañon City wagon-road to Pleasant Valley, in the valley of the Upper Arkansas, where Mr. Nell and a small party were detached to make a barometric profile of the Hayden Creek Pass, and to meander and locate the headwaters of Kerber Creek, a tributary of the San Luis, and the southern branches of Puncho Creek, and to join the main party near the head of the latter stream.

Having made a primary station upon the high peak at the head of the north fork of Puncho Creek, to complete the series of triangles established by me in Colorado in 1873, the party was divided, and the assistant topographer sent via the Coochetopa Pass to the Los Pinos agency, with orders to trace San Luis River to its head, while Mr. Nell and myself, with one packer, crossed the Atlantic and Pacific divide at the head of the middle fork of Puncho Creek to one of the tributaries of the Gunnison River, which we followed from its head in the pass to near its junction with the Coochetopa, connecting with the lines surveyed by Mr. Young of my party in 1873; thence via the old Gunnison wagon-road to the agency, making *en route* the necessary secondary stations with the gradienta on peaks, in addition to the regular stations.

The assistant topographer joined us on the 17th of August, and from this date until the 24th the party were employed in the vicinity of the agency in gathering topographical data, especially in the group of lofty volcanic peaks above the heads of Coochetopa Creek, which here form the continental divide.

On this date (August 24) the assistant topographer and party were sent via the trail from the Los Pinos agency to Antelope Park, in the cañon of the Rio Grande del Norte, to trace out the headwaters of that stream, while Mr. Nell and myself proceeded to the Uncompahgre Peak, which we occupied as as a primary point, spending upon its summit two entire days. Having occupied four other prominent stations, we joined the main party on September 5.

On September 9, having made stations on Canby and Pass Peaks, we crossed the divide at the head of the Rio Grande, and from this date until September 26 the topographer and myself were engaged among the difficult and intricate topographical features of the San Juan mining-district about the heads of the Las Animas, Uncompahgre, San Miguel, and Dolores Rivers; the assistant topographer having been sent via old Animas City to the Pagosa Hot Springs on the Upper San Juan.

It was my intention, after the necessary stations were occupied and the lines of drainage from the divide between the San Juan and Gunnison waters traced, to visit the Sierra La Plata and the headwaters of the Rio Mancos and Rio La Plata, and then return to the divide south of the Rio Grande headwaters; but on the 20th of September we were caught at timber-line in a two days' snow-storm, and after it was over, while making a station on a high peak at the head of the north fork of the San Miguel, both the topographer and myself were blinded by the dazzling reflection of light from the snow.

From my experience in these high mountains, I was led to believe that they would be closed by snow before the trip to the Sierra La Plata could be made, and our triangulation connected with the astronomical stations at Trinidad and Pueblo over the summits of the peaks along the southern side of the Rio Grande loup in the continental backbone. I abandoned, then, this western portion of the work and directed my attention to perfecting the belt of triangles from the two stations mentioned to the westernmost point attained by my party. Accordingly, we made stations on the most southerly of the high peaks south of the mines in the San Juan drainage-area, and then recrossed into the Rio Grande basin, and, turning to the south, attained the divide, and were engaged among the very rugged and high peaks about the heads of the Rio Los Pinos and Rio Florida, when we again encountered a four days' snow-storm, and were forced by the great depth of snow, from 18 inches to 3 feet, from the mountains.

The tributaries of the Los Pinos and Piedra were then meandered by us, and after having made several minor stations upon lower peaks near the head of the Piedra we proceeded for supplies to the Pagosa Hot Springs, which we reached October 8.

Upon the following day, the snow having meanwhile melted from the southern slopes of the mountains, Mr. Nell and a small topographical party went back to the group of peaks we named, from its pinnacled appearance, Florida's Comb, to again attempt to make an important triangulation-station; but since the peak could only be attained from the north, from which side the snow had not melted, the topographer was unsuccessful after several attempts, but the remainder of the time was profitably spent by him in gathering topographical details at a lower altitude.

As soon as the parties returned to camp at Pagosa, we proceeded to carry out, as far as practicable, the instructions we found awaiting us there. We proceeded up the main fork of the San Juan, the detailed topography adjacent to the eastern and western forks, and their drainage-lines, having already been secured, as I was informed by your party; but on the evening of the 18th of October it again began to snow, and the storm continued until the 20th. Upon its cessation, I sent Mr. Atkinson, Mr. Gilpin,

and one packer to meander the main San Juan to its head, to make stations with gradients, to locate the heads of the stream and of the western branch of the Rio Piedra. Upon the completion of this, they were to gain the cañon of the Rio Grande, and meandered the southern tributaries of that stream, which have their mouths between Antelope Park and the mouth of the south fork. This party, though experiencing very severe weather—the thermometer registering below zero—and much delay from the heavy snow upon the mountains, were successful in their efforts, and certainly deserve much credit for their resolution and self-sacrificing devotion to their work.

My own party, after making two triangulation-stations with 10-inch theodolite upon the most prominent peaks in this portion of the continental divide, attempted to gain the Summit mining-district by way of the heads of the South Fork of the Rio Grande, but on account of the slippery and unsafe condition of the steep sides of the cañon of this stream from snow and sleet, we were compelled to abandon the attempt, and to reach our intended triangulation points near the head of the Alamosa, via Del Norte. Upon reaching this point, I purchased the necessary supplies and provisions and immediately sent Mr. Nell and party, via the Los Pinos Creek trail, to the Summit mining-district to occupy the triangulation-points which had been selected in that vicinity, with directions that he should, upon the completion of his mountain-work, carefully meander the Rio Grande del Norte from the town of Del Norte to the Costilla Ferry, thence proceed to Costilla, thence meandering the Costilla Creek to its head, make a barometric profile of the Costilla Pass and of the road via the Vermejo Pass and the Purgatoire River to Trinidad. He was successful, in spite of snow, in closing, in a very satisfactory manner, our triangulation and in carrying out this programme.

Mr. Atkinson having arrived at Del Norte, I started with him and one packer, meandered the road from Del Norte to Conejos, thence to Fort Garland, thence to San Luis de Culebra, thence, via the head of the south fork of Culebra Creek, crossed over one of the highest points of the Spanish range to the head of the main Vermejo, which stream we meandered as far as the Elizabethtown road, and thence proceeded to Trinidad, where we arrived November 13, and where we found Mr. Nell and party engaged in selecting and marking out a base-line, to be measured by him, and developed from the astronomical station at this point to the principal peaks in the Raton and Spanish ranges, already occupied by other parties of the expedition.

On the 15th of November, I detached the assistant topographer and a small party, and sent them to gather topographical details in the drainage-areas of the middle and north forks of the Purgatoire River, to proceed to Pueblo for disbandment upon the completion of their work.

A base-line nearly six miles in length having been located and marked, and all the necessary arrangements to aid in its measurements and development, for the erection of artificial stations, &c., having been made, I left Mr. Nell and party to complete this work, and proceeded, November 20, to Pueblo, for the purpose of supervising the disbandment of the several field-parties of the expedition.

The measurement of the base line at Trinidad was completed by November 27, and the parties all disbanded at Pueblo, Colo., by December 2, 1874.

During the field-season, besides the executive charge of the party, I took the necessary sextant-observations for latitude at points which could not well be located by triangulation-methods; and when the party was divided, as was generally the case, I carried the cistern-barometer, and took and recorded the barometric and psychrometric observations, for hypsometrical purposes, for the division I accompanied, all of which observations I have since computed, and the results are in the hands of the topographers.

INSTRUMENTS USED.

The parties were well provided with instruments.

The triangulation stations were occupied with an 8-inch transit, made by Stackpole, reading by vernier to 10″ of arc. Minor stations were occupied with a gradienter, reading to 1′ of arc, and the meanders were executed with a Cassella theodolite, reading by vernier to 1′ of arc; the distances being measured by odometer, and checked by sights to points well fixed by triangulation. We carried two cistern-barometers, made by Green; two 3-inch aneroids, with attached thermometers, made by Cassella, of London; and two sets psychrometers for our hypsometric work, together with the necessary appliances for refilling and replacing broken barometer-tubes.

HYPSOMETRY.

The observations required by the printed instructions, compiled and prepared by Lieut. R. L. Hoxie, Corps of Engineers, for the guidance of members of the survey, were taken. These were, cistern-barometer and psychrometer observations at camps and upon triangulation and topographical stations, and aneroid and thermometer readings at all meander-stations.

The system of observation, instrumental comparisons, field-transcripts, and records, devised by Lieutenant Hoxie, has worked admirably during the past season, and has been fruitful of the best results. Especially useful is the combination of the records

of aneroid and odometer, whereby definite profiles are secured; also, the method of reduction of the aneroid work, whereby the effect of instrumental errors are nearly eliminated from the final results.

These observations, many hundreds in number for each party, have all been corrected for instrumental errors and horary oscillations, carefully computed, and the altitudes written upon the plats.

AZIMUTHS.

The triangulation-stations all being very far above the upper limit of tree-growth, and the peaks themselves seldom visible from any convenient camping-place where wood for fires could be obtained, it was generally impracticable, from cold, to take observations at night for azimuths of sides of the main triangles. However, at Simpson's Peak, a lofty mass above 14.000 feet altitude, at the head of the Rio Los Pinos, which I have named, with your permission, in honor of Col. J. H. Simpson, Corps of Engineers, who has done so much in the way of western exploration, quite an extended series of observations on Polaris were made by myself and Mr. Nell for azimuth; the time being determined by sextant and watch, and the observations taken near elongation.

At camps, the usual observations on Polaris at elongation for magnetic declination; and for azimuth, when we relied upon latitude and azimuth for the location of our camps, were taken, and have been computed. These results of single observations for magnetic declination, taken by the various parties of the survey since its organization at hundreds of places in the interior where this element of terrestrial magnetics has not been known, with nearly as close an approximation to accuracy as given even by our short needles and the coarsely-graduated arcs of our meander-theodolites, should now be sufficiently numerous to be of great value in the construction of general magnetic charts.

During the past season, I have always endeavored to have this element more accurately determined by attaching a needle to the telescope of the 8-inch transit used on our triangulation-stations, and causing to be measured as accurately as possible the angle between the magnetic meridian and a side of a main triangle, the azimuth of which is quite accurately given by the computation of the triangles.

The azimuth of the base-lines at Pueblo and Trinidad, in the measurement of which my party participated, was determined by elaborate observations made by Dr. Kampf with an 8-inch theodolite, in connection with an astronomical transit.

Respectfully submitted.

WM. L. MARSHALL,
First Lieutenant of Engineers.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

APPENDIX B.

EXECUTIVE REPORT OF LIEUTENANT P. M. PRICE, CORPS OF ENGINEERS, ON THE OPERATIONS OF PARTY NO. 1, SECOND DIVISION, FIELD-SEASON OF 1874.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., March 17, 1875.

SIR: I have the honor to submit the following report upon the operations of party No. 1, second division, while under my charge, during the field-season of 1874:

Upon taking charge of the party at Santa Fé, N. Mex., on the 3d of October, 1874, its *personnel* was as follows: Gilbert Thompson, chief topographer; Frank Carpenter, assistant topographer; Dr. Oscar Loew, chemist and mineralogist; L. H. Hance, meteorological observer; A. J. Tweed, odometer-recorder; two packers; one herder; and one cook.

The first work to be performed was the measurement and development of a base-line at this point. On account of the difficulty of finding, in the immediate vicinity of Santa Fé, a position suitable for this purpose, the plateau south of Tetilla Peak, and about fifteen miles southwest of Santa Fé, was selected. The base-line was measured twice with a compensated steel tape, 50 feet in length, under a pull of twenty pounds; the tape being set for temperature on the measurement of each length. Pegs were driven at distances of 200 feet apart, and at less distance when required by the nature of the ground. The difference of level between the consecutive pegs was afterward determined by leveling with a Y-level, and the corrections necessary to reduce the measured distance to a horizontal distance calculated and applied. The two measurements give 19391.027 feet and 19391.073 feet, a difference of 0.046 foot, and a mean of 19391.05 feet. The base-line was developed, and connected by good triangles with the astronomical

monument at Santa Fé, and with the system of triangles extending down from Pueblo. The angles were read from an 8-inch Stackpole transit, reading to 10″ of an arc.

I was directed to place in position the cut-stone astronomical monument and meridian-marks at Santa Fé. I found that Professor Safford had not marked the meridian, and that the observing-stone used by him was so situated that the meridian passing through it cuts houses about 30 feet to the north and south of it. I, therefore, placed the monument 5 feet 10 inches west of this stone. This position did not admit of the placing of a meridian-mark to the south of it, but enabled me to put up one on the *mesa*, at a distance of 1926.428 feet north of the monument.

The observations necessary for the determination of the direction of the meridian were made with a Würdemann portable transit. I am indebted to Lieut. C. C. Morrison, Sixth Cavalry, acting engineer officer of the district of New Mexico, for his kind assistance in this work, as well as for many other courtesies shown myself and the remainder of our party.

During the time occupied by Mr. Thompson in reading the angles at the stations selected for the development of the base-line and its connection with his triangulation-stations, Mr. Carpenter was employed in meandering roads and streams to the west and north of Santa Fé.

Our work in this country was finished on the 3d of November, and on the morning of the 4th, supplies sufficient to last until we should reach Fort Union having been purchased, the party left Santa Fé to proceed to Las Vegas.

It had been my intention to take the whole party to Las Vegas over what is known as the Fort Union trail, in accordance with your instructions requiring that trail to be surveyed; but recent snows in the mountains had rendered it impracticable for a heavily-laden pack-train. I therefore sent Mr. Thompson, with Dr. Loew and one packer, by that route, and proceeded by the stage-road with the main party, arriving at Las Vegas on the evening of the 6th. Mr. Thompson did not come in until the evening of the 9th, having experienced great difficulty in following the trail.

Another base-line was measured on the plateau two miles north of Las Vegas; the method employed being the same as that for the Santa Fé base, except that the pegs were driven at distances of 50 feet apart, and that three measurements were made instead of two. The three measurements give the following results for the length of the base-line: 8570.1429 feet, 8570.0927 feet, and 8569.9856 feet; the greatest difference being 0.1573 foot, and the mean of the three results 8570.0737 feet.

The ends of the base-line were marked by cut-stone monuments. A triangulation was made connecting the base-line with the astronomical monument in the plaza of the town. This was completed on the 15th of November, and on the following morning we left Las Vegas, and, in accordance with your instructions, made the best marching-time possible to Pueblo, reaching that point on the 26th. A delay of half a day was made at Fort Union for the purpose of procuring supplies. We suffered considerably from the cold the last two or three weeks, as a cold wind was blowing the greater part of the time, and on the 18th and 19th we had severe snow-storms.

Aneroid and cistern barometer readings were taken regularly, as required by the "Instructions concerning meteorological observations."

While the work at Santa Fé and Las Vegas was going on, Dr. Loew was constantly engaged in making trips to points of interest in the vicinity of those places for the purpose of collecti g zoological, botanical, and mineralogical specimens, and of gathering information relative to the agricultural and mineral resources of the country. He also obtained specimens of all the mineral springs met with, the analyses of which will prove very interesting and valuable. Great credit is due him for the indefatigable industry displayed by him during the season, as shown by the number and value of his collections.

I desire also to return my thanks to Mr. Gilbert Thompson for his efficient co-operation, and to bear testimony to the skill and energy with which he prosecuted his work.

Very respectfully, your obedient servant,

PHILIP M. PRICE,
First Lieutenant of Engineers.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

APPENDIX C.

EXECUTIVE REPORT OF LIEUTENANT R. BIRNIE, JR., THIRTEENTH UNITED STATES INFANTRY, ON THE OPERATIONS OF PARTY NO. 2, FIRST DIVISION, FIELD-SEASON OF 1874.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., March 9, 1875.

SIR: I have the honor to submit the following executive report of the operations of party No. 2, first division, during the field-season of 1874:

The party, as organized under your direction at the rendezvous-camp, Pueblo, Colo., consisted of F. A. Clark, principal topographer; W. H. Rowe, assistant topographer; A. C. Ladd, meteorological observer; J. W. Kurtz, odometer-recorder; two packers, one herder, and one cook, making, with myself, a total of nine persons.

We left camp at Pueblo, July 29, and our operations during the month of August carried us as far as old Fort Lowell, N. Mex., first occupying Cuemo Verde and the western of the two Spanish Peaks, thence along the eastern base of the Spanish range, crossing or meandering the course of the Cucharas and Purgatory Rivers, Vermejo and Costilla Creeks, and occupying peaks of the range for triangulation and topographical purposes.

We crossed the range by the Red River Pass, through which runs a very direct trail from Elizabethtown to San Antonio, N. Mex. A halt of several days was made in the vicinity of San Antonio to obtain the topography of the adjacent country. The party was then divided, and crossed the Rio Grande and its valley by two routes to San Antonio Peak, and then again dividing proceeded to old Fort Lowell; Mr. Clark crossing the headwaters of the streams that flow into the Chama on the north, the Ojo Caliente Creek, El Rito, Cangilon, Cebolla, Nutrias, and Nutritas Creeks. Trips to the adjacent country were made in several directions from Fort Lowell.

A supply of rations for forty days was received, and the party moved to Hediondo Lake, about twenty miles west, where the plotting of the routes meandered and the duplication of field-notes taken to this point was accomplished.

The party was divided to proceed to the San Juan River; Mr. Clark with Mr. Ladd and one packer by way of the Gallinas Mountains and Cañon Larzo, while with the remainder I pursued nearly a westerly course, meandering the Cañon Cenesal and making topographical stations upon prominent mesas.

The course of the San Juan was followed for about sixty miles, when we turned to the southward along the eastern base of the Tuni-Cha range to the villages of the Navajo Indians on Peña Blanca, Tuni-Cha, and Vaca Creeks. A trip was made by Mr. Clark and myself to the highest points of the Cariso Mountains, being the most western point reached by us.

Returning eastward, the party was divided at the villages; with one part I followed up the Cañon de Chaco, recrossing the Atlantic and Pacific divide into La Jara Valley a few miles north of Naciuniento, N. Mex., while Mr. Rowe, with two others, kept along the divide to the north of the Cañon de Chaco, passed by the springs Nuestra Señora and San José, Gallinas, Capulin, Punco, and Cannonus Creeks to Abiquin, where the parties joined.

Several points were occupied in this vicinity for triangulation and topography, and the meander of the Chama completed from Fort Lowell to near its junction with the Rio Grande. Some time was also spent in this camp to allow our animals, that were in a very poor condition, to recuperate, as for nearly six weeks they had had nothing but grass, and that often very scant; the supply of water also being very insufficient.

The notes and plats of the party were put in order here, and a supply of rations received.

The party next moved by trail to El Rito, while Mr. Rowe meandered Ojo Caliente Creek, meeting us at the Ojos Calientes. The Rio Grande was recrossed at the mouth of the Hondo by Mr. Clark, while the rest crossed at Embuda, passing over the unfinished portions of Lieutenant Ruffner's new road, and meandering or crossing the waters of Embuda, Peñasco, Picuris, Rio Grande, and Frijoles Creeks, visiting the towns of Ojo Salado, Chemisal, Peñasco, Llano, Santa Barbara, Picuris, and Los Ranchos, and joined Mr. Clark on the Rio Pueblo near Taos.

In crossing the range from Taos to Elizabethtown, we failed in attempt to occupy a high point lying between these towns, encountering a snow-storm, high winds, and extremely cold weather. The road through Taos Pas s to Elizabethtown and Cimarron was meandered, and a barometric profile of the pass made. At Elizabethtown, our meander-line was connected with that made early in the season, and thence the Moreus and Cienazilla Valleys and the Cimarron Cañon were passed through to Cimarron.

At Cimarron, a base was measured, and extended to connect the astronomical station established there by Dr. Kampf with the system of triangles carried over the area surveyed by the party. On November 23d Mr. Clark was left at Cimarron to complete the measurement of the angles about the base, while the party took nearly a direct route to Pueblo, meandering the route through Cerososo Cañon and Van Brimmer Park, and crossing the Vermajo Creek, thence returned by the same route it had pursued going out, and arrived at Pueblo November 28, and was disbanded within a few days.

A great portion of our area was poorly adapted for triangulation, on account of its mesa character. Sixteen peaks were occupied for primary triangulation and topography, and twenty-five others for topography and secondary triangulation, with about seven hundred stations *en route*, at which bearings were taken, together with barometric readings for altitude.

The triangulation was made with an 8-inch-plate theodolite, Stackpole & Brothers;

the instruments used for topography being the gradienter, small theodolite, Casella, prismatic field-compass, with cistern and aneroid barometers.

About two thousand nine hundred miles of route was traversed, and nearly all carefully meandered. Distance was measured by an odometer, (in some cases estimated;) and observations with the sextant for latitude taken by myself at camps that could not be located by bearings, and to serve as checks upon meander-lines.

Cistern and aneroid barometers were carried throughout the season; the cistern-barometers (and the aneroids for comparison) being read at all camps and prominent peaks, passes, &c., visited. Observations for humidity were taken at the same time. The magnetic variation was determined at each camp, when practicable.

My thanks are due to Mr. Morley, of Cimarron, for the hearty aid extended us while there, and to the members of the party for the manner in which they performed their duties, and by which each one served in augmenting the pleasure of the work.

Respectfully submitted.

R. BIRNIE, JR.,
First Lieut. Thirteenth Infantry.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

APPENDIX D.

EXECUTIVE REPORT OF LIEUTENANT STANHOPE E. BLUNT, ORDNANCE CORPS, ON THE OPERATIONS OF PARTY NO. 2, SECOND DIVISION, FIELD-SEASON OF 1874.

FRANKFORD ARSENAL,
Philadelphia, Pa., March 15, 1875.

SIR: I have the honor to submit the following executive report of the operations of the party No. 2, second division, during the field-season of 1874:

The party was organized at Pueblo, Colo., during the latter part of July, and was composed of the following persons: E. J. Sommer, topographer; F. O. Maxson, assistant topographer; B. W. Bates, meteorologist; H. G. DuBois, odometer-recorder; one cook, one herder, and two packers.

The country to be surveyed was bounded on the west by the road from Trinidad to Elizabethtown, N. Mex., and to the south of that by the divide of the main range; on the south by the latitude of Las Vegas, and on the east by 104° 7′ 30″ west longitude.

The party left Pueblo on the 20th of July, proceeding directly to Trinidad, Colo., by the stage-road, and after a delay there to make the ascent of Fisher's Peak, crossed the Ratton Mountains by the Ratton Pass, and for the next fortnight were engaged upon the country to the west of the stage-road, meandering the forks and branches of the Red, Vermejo, and Poniel rivers, and Crow, Van Brunmer's, and Cenososo creeks, as far to the west as the Elizabethtown road.

On August 17, I arrived at Cimarron, N. Mex., where a further supply of rations was to be sent me. They did not arrive until the 20th. The intervening time, however, was occupied in working up notes, and in meandering a small stream that had been omitted on the march to Cimarron.

I was obliged, on August 12, when in camp, on the Vermejo River, at the stage-road, to send Mr. Sommer, my chief topographer, to the hospital, at Fort Union, on account of sickness. His absence delayed me somewhat, as, with but one topographer for duty, I was unable to keep two topographical parties in the field, as I had previously done.

Mr. Sommer rejoined us at Elizabethtown on August 25; and from that time until the close of the field-season, one topographer was detached upon side-parties on every available opportunity.

After leaving Cimarron, and until September 10, the survey was conducted about the headwaters of the Cimarron, Moreno, Cienaguilla, Cimarroncito, Ryado, Urac, Ocate, Coyote, and the Mora, with its branches, and as far down these streams as the stage-road. During the time Mr. Maxson was absent from the party, on a trip of three days, to Elk Lake, at the headwaters of Coyote Creek, the primary triangulation-station west of Guadalupita was occupied, and such other secondary triangulation-stations as were necessary.

From September 11 to September 28, the party remained in camp at Fort Union. A base-line was measured at this point, and extended to the neighboring mountains, the necessary triangulation-stations for this purpose being occupied. Upon the completion of this duty, and after refitting and purchasing rations, we operated along the stage-road, through Las Vegas, Bemal Springs, and San José, until the primary triangulation-station, west-southwest of Pecos, that I had been directed to occupy, was reached. We were obliged to delay here three days, waiting for clear weather. After that, and until October 20, the survey was conducted in the mountains east of Santa Fé, and about the headwaters of the Pecos, Vaco, Tecalote, Sapello, &c.

After leaving the triangulation-station near Pecos, Mr. Maxson was detached on a side-party, rejoining us after seven days at Sapellotown; from that point Mr. Sommer and Mr. Bates were detached, and after a six days' absence rejoined me at Fort Union.

After further refitting at Fort Union, and purchasing supplies, sufficient with those left at Cimarron for the remainder of the field-season, we left that place on October 21, surveying down the Mora River to its junction with the Canadian, and up the Canadian to its junction with the Cimarron, and up the latter stream to Cimarron. It was found impossible to keep close to the bank of the Canadian; the river near its confluence with the Mora being in a cañon 600 or 800 feet deep, and the plateau above deeply cut up by numerous side-cañons, we were obliged to head it, being impossible to cross them with the pack-train. This cañon we found continued up the river almost to the junction of the Cimarron.

I reached Cimarron on the 29th of October. Mr. Sommer, who had been detached upon leaving Fort Union, with directions to move northward to the Cimarron River, keeping midway between the stage-road and the Canadian, also reached Cimarron the same night. Upon leaving Cimarron, after refitting, Mr. Maxson was detached and directed to cross the Raton Mountains by the Trinchera Pass, that being the most easterly pass within my portion of the survey. The remainder of the party continued up the Canadian River to Chico Rico Creek, and up that to its headwaters, crossing the mountains by the Manco Buno Pass, and thence skirted the northern base of the mountains to Trinidad, reaching that point on the 8th of November; Mr. Maxson also getting in on the same night. A delay of one day was made here while Fisher's Peak was being occupied as a triangulation-station. I left Trinidad by the stage-road to Las Animas, making one day's march along that, and then across to the north, to the Apisipah River. It was my intention to follow that stream to its junction with the Arkansas, but finding that it was perfectly dry, and that there was but little probability of obtaining any water along the proposed route, that fact and the condition of my stock of provisions decided me to return to Pueblo by the shortest route; the telegraph-road was accordingly followed, and Pueblo reached on the 14th of November. My party was disbanded at that place the following day.

About nine thousand square miles were covered by my party of the survey during the field-season, embraced upon portions of atlas-sheets 62^c, 69^b, 70^a, 70^c, 76^d, and 78^a. The total length of meander-line during the season was over 2,200 miles. Twelve primary triangulation-stations and thirty-one secondary triangulation and topographical stations were occupied, in addition to about nine hundred stations on the meander-line.

Connecting twice with the permanent astronomical stations at Trinidad and Fort Union, three times with that at Cimarron, and once with the station at Las Vegas, as well as the connections at the opening and close of the season with the Pueblo station, gave accurate checks at frequent intervals upon the meander-line. Sextant-observations for latitudes upon north and south stars, or upon the sun when practicable, were also taken by myself. Observations upon Polaris for magnetic declination were frequently obtained.

At all camps, readings of the meteorological instruments were taken every three hours from 6 a. m. to 9 p. m., when the camps were for a whole day, except when camps were in the vicinity of a permanent astronomical station, where they were taken hourly for twenty-four hours. Upon the march, the aneroid barometer was read at each station upon the meander-line, and the cistern-barometer also when the station was an important one. These observations were continued until late in the field-season, when the cistern-barometers getting out of order, and being unable to repair them in the field, these observations had to be discontinued.

Both Mr. Sommer and Mr. Maxson, the topographers, as well as Mr. Bates and Mr. DuBois, performed their duties during the entire season in a manner perfectly satisfactory.

Very respectfully, your obedient servant,

STANHOPE E. BLUNT,
First Lieutenant of Ordnance.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

APPENDIX E.

EXECUTIVE REPORT OF LIEUTENANT C. W. WHIPPLE, THIRD UNITED STATES ARTILLERY, ON THE OPERATIONS OF PARTY NO. 1, FIRST DIVISION, AND SUBPARTIES, FIELD-SEASON OF 1874.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., April 24, 1875.

SIR: I have the honor to submit the following brief summary of the operations of the parties under my charge during the past field-season:

Leaving Rendezvous Camp at Pueblo, Colo., on the 1st day of August, with a small party of five members, associated with Lieutenant Marshall's party, the road was meandered south of the Arkansas as far as Cañon City. From there, crossing the

mountains by the very difficult pass of Grape Creek Cañon, which is about thirty miles in length, we found displayed in miniature all the remarkable features peculiar to the larger and more celebrated passes in that section of the country, and in which was no trail or any other indication that others had been there before, the party passed down by Wet Mountain Valley through Ula and Colfax and by the Moscas Pass to the San Luis Valley, a single day's march, but a rough one, around the base of the Ceno Blanco, to Fort Garland, where it was joined to the main division August 10.

On the 13th, the same party, with the addition of Mr. Aiken, taxidermist, left Fort Garland, and following up Indian Creek, made stations on two peaks near its headwaters. Crossing the divide, we kept down a creek of this same name, and moving south around the bases of the higher mountain, which faces on the north the Spanish Peaks, struck the Cucharas, and the road on its banks, which we followed some miles, and then the mountains were crossed through a gap and the headwaters reached of one branch of the Trincheras. Thence we moved down the San Luis Valley, through the San Luis and Lower Culebras, along the Culebras River to the Rio Grande, to the junction of the Conejos and San Antonio Rivers, and through the playas which border the river to Guadaloupe, where again was found encamped the main division. Two days later, on the 24th instant, I was left by you in charge of the main division, and marching along the Conejos encamped on that creek almost west of Prospect Peaks, where you on that day proposed to make a station.

Until September 6 I remained in the capacity of executive officer with the main division during its movements up the valley of the Conejos, across to the Alamosas, and up to its headwaters, across the divide to the San Juan and down its valley to Pagosa Springs.

On the 8th instant, with a small party, I moved south by the road to Tierra Amarilla, left it where it crosses the Navajo, and kept along that stream to its junction with the San Juan; moving south and east from there, we crossed the Tapiacetas Mountains, struck the old Spanish trail, passed the Lagunas de los Piedras, made a station on one of the Las Gallinas Mountains in that vicinity, and reached Tierra Amarilla (the Nutritas Playas) on the 13th instant. On the next day, we followed the north fork of the Chama to near its headwaters, made a station on Navajo Mountain, and an unsuccessful attempt on the Banded Peak to the eastward, crossed both branches of the Navajo, and striking the wagon-road to Pagosa, near the Blanco, reached camp at that place on the 19th instant. Sending out a small party under Mr. Spiller, to occupy the Banded Peak, I remained at Pagosa Springs until his return. On the 1st day of October, I started with the party, which from that time constituted party No. 1, main division, and was composed as follows: J. C. Spiller, topographer; William Blount, meteorologist and odometer-recorder; D. Y. Mears, chief packer; Aleck Hurlston, packer; Caesario Frahijo, packer; George Badger, cook.

Moving east, we followed up the first fork of the San Juan to the northward to its headwaters. It was the intention to occupy the double-capped mountain known as Pagosa Peak. A severe storm of a week's duration detained us at its base, and covered the mountain with several feet of snow. On the sixth day, the top was reached, waiting all night in the vain hope of catching a glimpse of the surrounding country, with animals and men pretty well worn out; we again started west across the upper waters of Los Piedras, up the valley of the Los Pinos to its headwaters, and over the divide to the Rio Grande. Following its waters to their head, I crossed into Baker's Park by the trail through Cunningham's Gulch, and, passing through Howardville and Silverton, moved up Mineral Creek and across the divide to the Lake Fork. The summit of this divide is 12,410 feet in height, and the descent remarkably steep. Near this summit is a very deep, dark-colored lake, about a fourth of a mile in diameter, inclosed by very precipitous mountains perfectly barren and covered with snow. Nearly 3,000 feet below it, and perhaps five miles away, is Trout Lake, about a mile long by a third wide. Beautifully-wooded foot-hills of mountains far back, sloping gently toward its banks, form a marvelous contrast in warmth of effect to the cold, still, desolate picture above. The descent was most remarkable; a mass of broken stones covered the sides of the mountain, which was loosened by the frosts and melting snow, and in one place animals and men slid and rolled or pitched downward in an indiscriminate mass through a descent of perhaps a thousand feet.

From Trout Lake we moved west, and struck the valley of the Dolores, and camped for one day near the foot of the Glacier Peak (since named Meigs Peak) of the San Miguel range, which the topographer of the party, Mr. Spiller, occupied with partial success. I directed the march so as to strike the Manco near its mouth by passing between the Mesa Verde and La Late range, our animals being nearly worn out. I left orders for most of the party to await my return in three or four days at a camp on Gothic Creek, and started down the cañon of the San Juan. For about fifty miles I followed the river through a charming country, though progress was difficult on account of the heavy underbrush and the boggy condition of the soil. Streams of considerable size flow in on both sides at frequent intervals. The mountains on the south are heavily timbered with pine; on the north but sparsely, and principally with cottonwood. The rock-formation is very peculiar, and lines the northern sides of the

valley with grand palisades of sandstone and limestones, which have been washed into many fantastic shapes. Game was exceedingly plentiful, and the bears so purposely deliberate in their attempts to avoid us as to bear testimony to the infrequency of these disturbances. I passed by two deserted cabins labeled "The Dolores Mines," which it appeared had been left the 1st of August, and where a much-neglected garden showed the capacity of the soil. On the same day I passed a cluster of small lakes of bubbling water, raised on one bank above the level of the river, and showing symptoms of the presence of sulphur. I left the river and climbed the mesas on the south side, near the great bend of the Dolores, which had here reached such dimensions that we forded it with difficulty.

Striking west, we marched through forests of immense pine, which gradually sunk into piñon and juniper, and finally into scrub-oak, and a thick undergrowth of Spanish bayonet. Crossing Macomb's trail, the country became more and more open as we descended into the immense basin before us. Pottery was everywhere scattered over the ground, and at intervals traces of ruins appeared, the first I had seen. A curious one I examined at the lowest point of this basin, in a gulch, where, for the last time till I struck the Mancos, I found water in pockets. The ruins were located under an overhanging cliff of sandstone, and consisted of a number of cells made of rough stone masonry, formed against the side of the cliff like a cluster of swallows' nests. Later, at the foot of Darling's Peak, much more extensive ones were found, with well-built walls standing 8 or 10 feet high, and the outlines of an estufa. For three days we marched through this country before reaching the Mancos with neither water, wood, nor grass; even sage-brush and soap-weed occurred but in occasional patches. The country was perfectly sterile, but wonderfully picturesque. On the east the mesa-benches were crowned with vertical walls, from 300 to 500 feet high, the appearance of immense battlements, flanked and guarded by towers. On the west rose Late Mountains, and far away toward the south loomed up The Needles from beyond the San Juan.

Moving down the Mancos, at intervals of every few miles I passed ruined towers, many of them quite well preserved, circular in shape, with a diameter of not more than fifteen feet. They were on each side of the river, and it seems peculiar, as if they were intended for watch-towers that never were placed in any commanding sites, the mesas rising in terraces behind them affording far better positions.

At the mouth of the river, on the north side of San Juan, illy-preserved but extensive ruins were found, both on the mesas and at the foot of the cliffs near the river-banks.

Having lost one of the animals, the condition of the remainder forced us to give up our intention of proceeding farther; so, leaving the river, we climbed the mesa and made a forced march to the point on Gothic Creek selected for rendezvous. Finding no water the next morning, we moved east, meeting the rest of the party on the march, and with them returned to the San Juan, and encamped opposite the mouth of the Mancos.

Leaving there October 30, I followed the river on the south side to the head of the Governor's Cañon, past the Lagunas de las Piedras, and reached Tierra Amarilla November 9. Through much snow I then crossed the mountains by the trail from the south fork of the Chama, passed through Conejos, and, following the Conejos and Tuncheras rivers, reached Fort Garland in a heavy snow-storm on November 19. Finding instructions there to proceed to Pueblo with the least possible delay, we crossed the mountains by the Sangre de Cristo Pass and reached Pueblo November 24.

I wish here to bear testimony to a cheerful performance of duty by every member of my party under circumstances of unusual exposure and privation, and to thank them for the courtesy which they at all times displayed.

I am, sir, very respectfully, your obedient servant,

C. W. WHIPPLE,
Second Lieut. Third Artillery.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

APPENDIX F.

METEOROLOGY AND HYPSOMETRY, FIELD-SEASON OF 1874, BY LIEUTENANT W. L. MARSHALL, CORPS OF ENGINEERS.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE 100TH MERIDIAN,
Washington, D. C., April 30, 1875.

SIR: I have the honor to submit the following report upon the barometric work of the past season, together with a brief description of the system of observation, record, and reduction in use upon the survey since I have been in charge of this branch of the work.

The present efficient state of this department is largely due to the efforts of Lieut. R. L. Hoxie, Corps of Engineers; the methods prescribed by him, both for field and office, having been adhered to, with modifications, by myself and assistants.

FIELD-OBSERVATIONS, COMPARISONS, RECORDS, AND TRANSCRIPTS.

Before taking the field, the office-standards were compared with those of the United States Army Signal-Office, and the remainder of the instruments with these office-standards, to determine the errors of the barometers and thermometers. From the office, the instruments were carefully transported to the field by hand, to guard, as far as practicable, against forced changes in their relative errors. Upon the arrival at Pueblo, Colo., they were all again compared hourly pending the organization of the expedition, which furnished a means of checking the errors already determined at Washington, D. C., and of deducing the amount of change in the adjustment of such barometers as were affected by transportation.

As soon as the organization of the field-parties was effected, the barometric observers were carefully instructed by yourself and by me in their duties, and in regard to the care, repair, and transportation of barometers and meteorological instruments. Each field-party was provided with two of Green's mercurial cistern-brometers, reading by vernier to 0.002 inch; two sets of psychrometers; from two to five aneroid barometers, with the necessary pocket-thermometers to be used in connection with the aneroids, and with one box of implements and eight empty tubes for refitting broken instruments.

Every person who had charge of a barometer was furnished with printed instructions as to its use, and with the necessary ruled and headed blank books and forms of record for intelligibly recording his observations; and it was made imperative that all observations should be recorded upon these forms, to prevent loss and confusion.

The observations taken by members of the field-parties were:

1. Cistern-barometer and psychrometer observations in camp every three hours, or at 7 a. m., 2 p. m., and 9 p. m., at which hours also *all* meteorological instruments of the party were compared for determining the altitudes of camps and to furnish the means of detecting changes in instrumental errors.

2. Cistern-barometer and psychrometer observations upon peaks and topographical stations, simultaneous with observations in camp.

3. Aneroid and thermometer readings, in connection with the odometer at meander-stations, for securing definite profiles of the roads, trails, &c., and the gradients of passes. At important points along meander-lines, at towns or settlements, and upon the summits of divides, &c., cistern-barometer and psychrometer were also read.

4. Aneroid and thermometer readings, taken by various members of the different parties at important points which can easily be identified and located upon the map without the aid of the topographer.

In addition to the above readings, taken for hypsometric purposes alone, general meteorological observations, such as are prescribed by the Smithsonian instructions, were taken and recorded, and furnish valuable information in regard to the climate and meteorological conditions of the regions surveyed for the time of the year the parties were in the field.

Whenever a camp was established for several days, hourly observations were taken, from which tables of horary corrections have been formed, and used in the reduction of the aneroid work and isolated observations. Such tables were secured, including the astronomical station of 1873, for Hughes, Georgetown, Colorado Springs, Pueblo, Labran, Trinidad, Fort Garland, and Pagosa Hot Springs, in Colorado Territory; Cimarron, Fort Union, Las Vegas, and Santa Fé, in New Mexico. A permanent station was established at Pueblo, Colo., and continuous observations have been voluntarily taken during the past winter by Mr. S. F. Parish for the use of the survey.

Exclusive of those for the hourly work, the blank books and forms for the record and reduction of these observatiens are six in number. I have appended hereto copies

of these forms, filled out and with the reductions performed, selected at random from the records of the past field-season. They are given here because they may be of use to officers of the Army engaged in the performance of similar duties, who may desire such blanks; and they are valuable as the results of four years' experience in the field, during which the constant attention of yourself and the officers and assistants on the survey has been directed to the perfecting and simplifying the forms and systems of observation and record employed in the various branches of the work.

Form I, "Meteorological observations in the field," is for the general meteorological record, upon which is recorded the observations, at stated intervals, upon cistern-barometers and upon all meteorological instruments when assembled daily for comparison. Each individual of the party having meteorological instruments assigned to him turns them in to the meteorological observer upon his arrival in camp, for comparison, at prescribed hours, with the standards of the party, and the results are entered, with the general meteorological record, upon this blank form as well as in some cases, to be referred to hereafter, upon Forms III and IV. Blank spaces are left for correcting the readings of the standard barometer and reducing them to 32° Fahrenheit, in order that the errors of the aneroids may be at once determined for use, as explained hereafter in treating of aneroids. This form, as well as Forms III and IV, is bound in convenient shape for the pocket, with instructions as to its use printed upon the fly-leaf.

Form II is for the clean transcript of the general record; for tracing out the errors of the various instruments; for the correction of observations for instrumental errors; and, in fine, for the preparation of the observations for final computation of altitudes. This transcript is made in the field, and not only serves as a guard against loss by duplicating the record, but also very materially aids and hastens final results in the office, whither this record is sent as soon as the transcript-book is filled. The necessary instructions as to its use are printed at the bottom of each page, so that no observer of ordinary intelligence will make mistakes in the proper arrangement and grouping of his observations. To guard against errors in transcribing, the executive officer in charge of the party is required to compare the transcripts with the original records, and upon forwarding them to the office to certify that this comparison has been made by him. This blank form, when properly filled out, will then show a continuous record of the comparisons of all the instruments of the party, and give the data for all such hypsometrical determinations as depend upon a series of cistern-barometer readings.

In the field, simply the transcript of the record is made upon this form, and all the reductions are made upon it after it has been received at the office. It is bound in quarto size, with stiff pasteboard backs, that the record of each party may be preserved separate, that the data for any of our hypsometric determinations may be readily found, should any one ever wish to recompute them, and to give a firm support for the paper in transcribing upon it in the field, where a table cannot easily be carried.

Form III is for the record of such aneroid and thermometer readings as may be taken by individuals not connected with the topographical party proper, at prominent points which may be identified upon the map from the description alone, without the direct intervention of the topographer or his assistants. As can be seen from the form itself, it is intended that each individual shall compare his aneroid with the principal barometer before leaving camp, and immediately upon his return, and enter the readings of both instruments in this book. Since these comparisons are not usually made at the prescribed hours, they may or may not be entered on Forms I and II, and although the errors of the aneroids are deduced from those forms, this comparison is imposed only as a further safeguard against loss, that we may have the necessary data for numerous hypsometrical determinations, should even all the books save one be lost.

Form IV is the aneroid and odometer record. At each meander-station made by the topographer, including always the stations upon entering and leaving camps, the odometer-recorder enters the time of day, aneroid and thermometer and odometer reading, and the topographer locates the point either by angles between well-fixed points, or from his meander-bearings and measured distances. The aneroid is read both in feet and inches: in feet, for the convenience of the topographer in making his field-sketches; and in inches, for the more accurate determination of altitudes by computation. The altitude of numerous points in the neighborhood of these stations depends upon them for their approximate determination from angles of elevation or depression.

Form V is for the transcript made in the field from the "Aneroid readings," (Form III,) and the "Aneroid and Odometer" books, (Form IV,) and for the final computation of the altitudes and profiles deduced therefrom. As the method of treating aneroid observations is, as far as I am aware, altogether novel, and moreover, from the facility and rapidity with which the reductions are performed, is likely to be of great use in its application to preliminary surveys for routes of communication, and in securing general profiles of lines, the reasons which have led to its adoption, and the method itself, will be more fully described hereafter in this report in treating of aneroid barometers. As with Form II, this transcript must be carefully compared with the origi-

nal records by the chief of party, assisted by the barometric observer, and as soon as the book is filled, it is forwarded to the office, with his certificate that it is a true copy.

Form VI is for the computation of altitudes from synchronous observations of barometer, thermometer, and psychrometer at two stations. It is made to conform to the tables in the appendix of Colonel Williamson's paper on the "Use of the barometer, &c." It needs no description, and is not inclosed herewith.

For the field, then, we have three books of record, (Forms I, III, and IV,) sexigessimo in size, and two books for transcribing and duplicating these, (Forms II and V,) of quarto form. The meteorologist has simply to read all the instruments at the hours prescribed and record the observations, to furnish the reading of his barometer and attached thermometer when demanded, and afterward, at times prescribed by the chief of party, to transcribe all records, as he finds them, upon Forms II and V.

OFFICE-COMPUTATION OF ALTITUDES; ANEROID BAROMETERS AND PROFILES.

In the office-work, I have been ably and efficiently assisted by First Lieut. Rogers Birnie, First United States Infantry; Hospital-Steward T. V. Brown, United States Army; and Mr. F. M. Lee; and by the exertions of these gentlemen the work is nearly up to date.

The order in which this work has been performed, and its character, is as follows:

1. The comparisons of instruments at Washington, D. C., and Pueblo, Colo., were reduced, and the error of each instrument at the date it left the rendezvous-camp at the latter point determined.

2. The field-transcripts of the various parties were examined, the records of the instruments traced, the standard barometer and its error at each comparison determined, its readings corrected and reduced to 32° Fahrenheit, and, by comparisons with its reading and that of its attached thermometer, the errors of indices of all other instruments determined, their readings corrected thereby and reduced, and the force of vapor and relative humidity from psychrometric observations computed.

3. All hourly observations taken by the various parties were corrected for instrumental errors, reduced to 32° Fahrenheit, and erratic observations corrected, copied upon the hourly forms, and reduced to level by Colonel Williamson's second method, and horary tables formed, which, in connection with the barometric records at the main astronomical stations, gave us twelve tables of horary corrections in or adjacent to the area surveyed in 1874, for altitudes varying from 4,500 to 8,600 feet, within which limits nearly all the aneroid work, in connection with which the tables were principally used, is included.

4. Observations taken at hours differing from those of the Signal-Service, and all aneroid observations, were either corrected by interpolation or by the horary tables, and the means of barometer reduced and relative humidity taken.

5. The observations taken by the Signal-Service of the Army at Denver, Colorado Springs, and Santa Fé, for the time our parties were in the field, were transcribed, and these stations referred to each other by means of the six months' series, and the altitudes of the two last mentioned reduced.*

6. The altitudes of all camps and stations where cistern-barometers were read for a number of days were computed by referring them, by the mean of the series, to synchronous observations at the nearest of the signal-stations, and, of all camps and other points where isolated observations were taken, were deduced either from synchronous observations or from daily means; the observations having been corrected for horary oscillation, and referred either to our semi-permanent camps or to the Signal-Service stations mentioned. These determinations number over seven hundred.

7. The altitudes of all aneroid stations were computed on Form V wherever a continuous series of observations and comparisons with cisterns were found. Isolated readings, when comparisons have not been made for several days, and where subsequent and anteror comparisons do not show a nearly constant index-error, have been almost always rejected as unreliable for absolute altitudes, but have in many cases been computed on Form VI for the information of the topographers in constructing their maps. The altitudes from this source which have been computed number between three and four thousand, and give continuous profiles along about *ten thousand miles measured and meandered lines.*

8. Upon the completion of the computation of altitudes, all cistern-barometer deter-

* The altitude of Colorado Springs is well known from actual leveling; but upon comparing with the Signal-Office barometer at Santa Fé, I found reason to believe that its error is different from that given by the Signal-Office. Fearing that the same might be true of one of the barometers at the other stations, I preferred to use the relative altitudes as given by the six months' barometric observations referred to each other to the rigid level-lines. It is susceptible of easy demonstration that if the barometer at either of the intermediate stations has a very appreciable undetermined error, this course is the best for all observations referred to that station.—(W. L. M.)

minations were copied into the proper record-book, grouped by seasons and parties, and the locality of each point described as nearly as practicable; afterward the whole were thoroughly indexed for facility of reference, and the final results furnished the topographers for inscribing upon their maps.

9. Since April 1 the force has been engaged principally in preparing condensed tables and summaries of the observations taken at the hourly stations established by the survey since its organization. These are quite numerous, and the work of preparing the results for publication is slow and tedious. I hope, however, that it will be completed by the expiration of the present year.

ANEROID BAROMETERS.

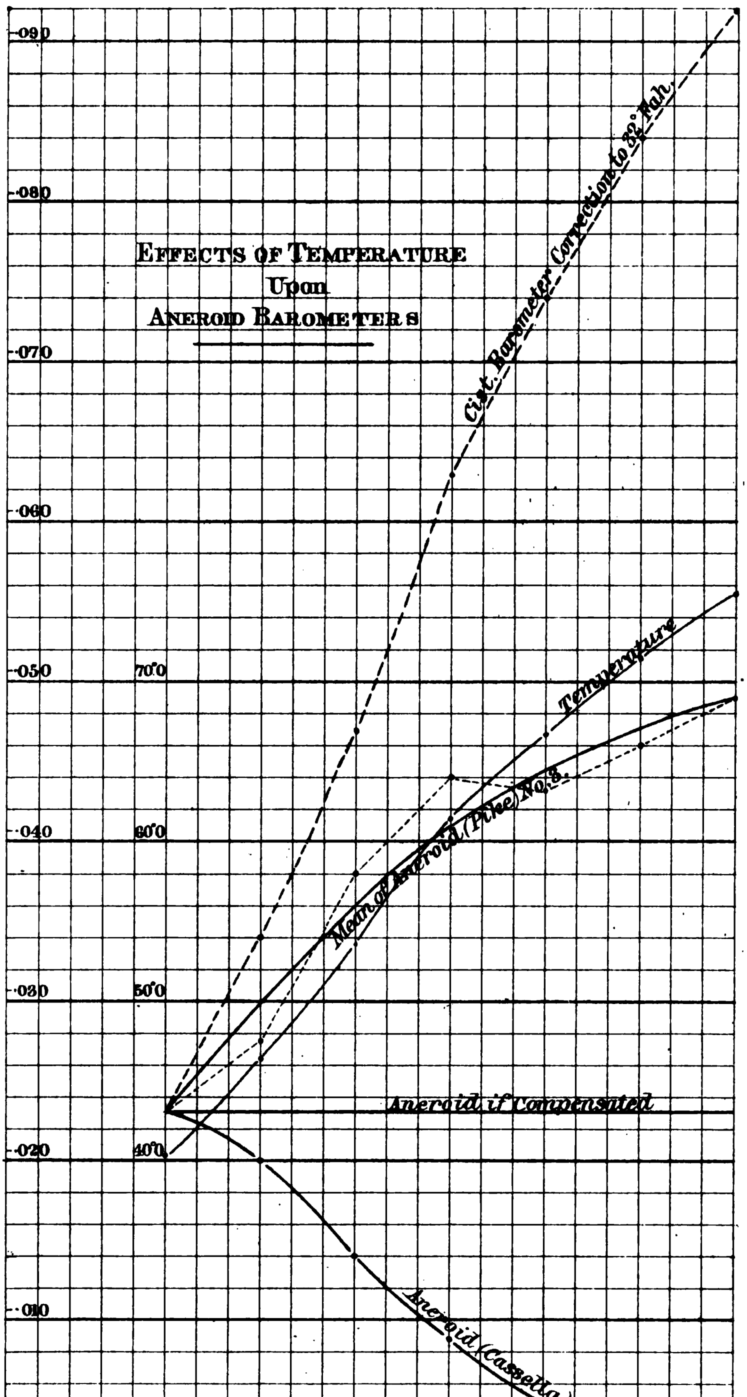
Since the organization of the survey, aneroids have been used by the topographers and geologists for relative altitudes, and, if properly handled, are a very useful and convenient instrument. Prior, however, to the season of 1873, so little was known by the individuals using them of their action and capabilities under the necessarily rough usage they must encounter in the field, and so much faith was placed in their indications and in the reports of too interested individuals as to their accuracy and constancy, that frequent comparisons with the more reliable mercurial barometers, which are absolutely essential if results of value are to be confidently expected, were neglected, and when the mass of aneroid work came to be examined and computed, it was found useful only as indicating the utter worthlessness of this machine for absolute altitudes when not used in connection with the mercurial barometer or the level. Like all other mechanical combinations of levers, screws, and springs, they are subject to continual shifting of parts when subjected to the jars and jolts encountered in ordinary use in the field, and it is essential that a continual watch be kept upon their indices of error by comparison with a more constant instrument.

Aneroids on this survey have been known to keep a nearly constant index-error for months; but this is an exception to the general rule of change. I give below, in this connection, a series of comparisons of several aneroids with the cistern-barometer at 32° Fahrenheit, copied directly from the field-transcripts in the order in which the comparisons were made.

TABLE OF ANEROID COMPARISONS, 1874.

Date.	Number of comparisons.	Cistern, at 32° F.	Aneroids, errors of, on cistern.					
			No. 1583, (by Casella,) error.	No. 1716, error.	No. Nickel, (by Green,) error.	No. 3 Pike, error.	No. 2 Pike, error.	No. 1719, (by Casella,) error.
			"	"	"	"	"	"
July 29–30	4	25. 148	+0. 762	+0. 279	....	....	....	....
July 30–31	4	24. 313	+0. 782	+0. 334	....	....	....	....
July 31 to August 1	3	23. 962	+0. 908	+0. 499	....	....	....	....
August 1–2	3	23. 180	+0. 829	....	....	....	....	....
August 2–5	22	23. 114	+0. 883	+0. 567	....	....	....	....
August 5–6	3	21. 413	+1. 136	+0. 594	....	....	....	....
August 6–7	2	24. 211	....	....	+0. 031	+1. 967	....	....
August 10–17	32	22. 657	....	....	+0. 021	+3. 137	+0. 862	+0. 357
August 17–18	2	23. 021	....	....	+0. 016	+3. 039	+0. 921	+0. 361
August 18–24	17	23. 701	....	....	−0. 008	+3. 173	+0. 949	+0. 363
August 24–26	5	22. 245	....	....	−0. 041	....	....	+0. 374
August 28	2	21. 839	....	....	−0. 091	+0. 559	....	+0. 369
August 29	2	21. 873	....	....	−0. 064	+0. 535	....	+0. 340
August 29–30	2	21. 907	....	....	−0. 482	+0. 552	....	+0. 387
November 3–4	2	22. 288	−0. 032	....	....	....	....	....

A difference not exceeding 0.03 inch may be allowed between any two comparisons for parallax, incapacity of the observer to subdivide the scale closely, and to the fact that the weight of the machine itself affects its indications, and an observer may not, even though cautioned on this point, hold the instrument in the same position when taking the two readings, when one may be made by daylight and the other by candle-light. This error of 0.03 inch between two readings would be very considerably reduced when two sets of readings, of three or four comparisons in a set, are taken. A simple application of the doctrine of probabilities will convince one that the changes visible in the index-errors of the aneroids from those comparisons where from three to thirty observations have been made at each camp are not so much due to errors of observation as to changes in the zero-point of the instruments themselves. In the table, the height of the barometer, reduced to 32° Fahrenheit is also given, to show, if such evidence is conclusive,



Effects of Temperature
Upon
Aneroid Barometers
·090
·080
·070
·060
·050
·040
·030
·020
·010
·000
70°0
60°0
50°0
40°0
Cist. Barometer Correction to 32° Fah.
Temperature
Mean of Aneroid (Pike) No. 3.
Aneroid if Compensated
Aneroid (Cassella) 1718.
Barometer at 32° Fah.

that these changes are not due to defective graduation, since I have selected observations where each cistern-barometer reads nearly the same at two or more of the camps given in each series. Nor were the adjusting-screws of the aneroids touched, as shown by the records of these instruments. In fact, many of the aneroids are so constructed that these screws cannot be reached without the trouble of unscrewing and removing a plate upon the back of the instrument, which the ordinary observer is not likely to take without positive orders to that effect. The observers were young gentlemen of more than average education, and the results are undoubtedly as good as may be expected from observers who have been instructed in their duties and conscientiously perform them. My object is to show in this discussion what is actually attained in practice with proper care, and not to select observations with a view to call attention to undue accuracy or to the want of it.

From these observations, it can be seen at a glance that it would be inadvisable to rely upon these instruments for any length of time for absolute altitudes without checking their indices by comparisons with those of the mercurial barometer, since the results would not only be affected by the ordinary sources of error due barometric determinations, but also those due changes in the zero-points of the aneroids themselves. Besides this source of error, aneroids are not always perfectly graduated, though the best English aneroids are well and carefully marked; but, from the nature of the case, only a few points of the scale are in the first place accurately determined, and the intermediate divisions are measured off, and afterward, if required, the instruments are tested under the air-pump through the entire scale. This should always be done, and a table of scale-errors accompany each instrument. In reducing our work, I have found it impracticable to correct for scale-errors, or even to determine their amount. Comparisons have been made at many points varying in altitude between 4,500 and 14,000 feet; but these comparisons are worthless for determining errors of scale, since it is in most cases (save where the index-error of the instrument remains constant) impossible to separate these errors from changes in the position of the zero-point. In individual and rare cases, it may be practicable to determine these errors by comparison with a good cistern at various altitudes; but in order that this method be successful in general, it is necessary to pass through the range of altitude in a short time, as during the ascent of a mountain, and to make the comparisons very frequently, and in any case to transport the aneroids with the greatest care, avoiding all jolts and jars, as we would with a chronometer or other delicate piece of mechanism. This, at least, is the conclusion to which I have come after the examination of the records of some eighteen aneroids during an entire season of four months, where a rigid system of comparison at various altitudes was enforced.

During the past field-season, wherever hourly observations were taken, all aneroids which could be assembled were compared at each hour with the cisterns, which gave series of comparisons extending over several days and through quite wide ranges of temperature, when the instruments were undisturbed, and therefore their index-errors presumably constant. I have examined all these comparisons, and, as far as they furnish data, have determined, as well as I could, the effects of temperature upon many aneroids, in practice. The instruments were made by Pike, Ewing, and Casella, principally by the latter; of pocket size; graduated to 0.05 inch, but susceptible of being read to hundredths of an inch by estimating the smaller subdivisions. I have first taken the difference between the indications of each aneroid and the corresponding readings of the barometer at 32°, to eliminate the movement in the barometric column itself, and then grouped the temperatures and the corresponding differences according to the ascending scale of temperature, and taken the mean of each group. The result has been an ascending scale of temperatures and a corresponding scale of aneroid differences, which I have plotted, together with the curve, showing the effect of temperature upon the height of the mercurial column at the altitude in which these comparisons were made. In a great number of cases I have detected no well-marked law of variation, especially among the aneroids made by Casella. Certainly, in these cases the want of compensation for ordinary ranges of temperature affects the readings by a quantity less than the errors of observation. Others show their want of compensation even in a short series of comparisons, where errors of observation are not sufficiently eliminated to give smooth curves. Of these, some are *over*-compensated, or the movement produced by heat is the inverse of that produced in the mercurial barometer; others are *under*-compensated, or the movement is in the same direction as the temperature. It is probable that no aneroid is perfectly compensated; but it is certain that in a great number, perhaps in the majority of instruments in use by us, this desideratum is so nearly approximated that for all intents and purposes it is practically attained for ordinary ranges of temperature. But, before we accept an aneroid as reliable in this respect, we should first satisfy ourselves by examination that we have not an exceptionally poor one. I give herewith the plotted curves relating to two of the aneroids examined, plotted upon a very large scale, greatly exaggerating the aneroid curve, which, in the two cases given, is not of great amplitude. Of all the aneroids examined, but one shows a greater range of variation than the two given upon this

plot, which are selected because they show both under and over compensation, and because the observations and comparisons having been made at the same temperatures, they can be plotted together. In no case have I found the aneroids affected by an amount exceeding one-half the reduction to 32° Fahrenheit of a mercurial barometer, at a mean height of 22 inches, for a range of temperature of from 35° to 40° Fahrenheit, and since this, even in extreme value, is less than the smallest subdivision of the aneroid's graduated face, and not perhaps far exceeding the ordinary errors in reading the instrument, I have not directly corrected for it, especially since I do not feel justified in making tables of corrections for temperature to be applied to aneroid readings from the defective data at my command. It would take much longer series of careful comparisons of each aneroid, through a wider range of temperature, to properly eliminate errors in the individual comparisons, and give us the true movement of the instrument, which is only indicated approximately by the tables I have formed and represented on the plate; but it seems to me that they indicate enough to make it clear that no very material errors in the results, computed as they have been, can be due to this cause.

The aneroids to be used in future upon this survey have been made to order by Casella, of London, are 3 inches in diameter, with attached thermometers, and a movable scale of feet. The graduation upon the scale of feet is made by one of the usual barometric formulæ, where there is no special term for humidity, leaving out the correction for the variation in the force of gravity upon the mercurial column, the zero or reference plane being assumed where the mercury stands at 30 inches and the mean temperature at 50° Fahrenheit.

When, therefore, these conditions are fulfilled, the indications of the aneroid in feet in latitudes where this datum-plane coincides with sea-level will give directly the approximate altitude of the station above the sea, provided the aneroid-errors be corrected for. To enable the observer to correct for index-error, and to avoid the necessity for his adding or subtracting a constant quantity to the indications of his instrument, is the object of the movable scale.

The aneroid, before the day's work begins, is compared with the mercurial barometer at 32° Fahrenheit, and its index-error determined. The zero of the scale of feet is then set by turning the movable ring upon which the scale is engraved to the right or left of 30″.0 by a quantity, expressed in inches of the scale, equal to the index-error of the instrument; the effect is to keep the zero of the feet-scale at the constant datum-plane where the cistern-barometer at 32° Fahrenheit would stand at 30″.0. Altitudes, then, read off the face of the aneroid, are affected by the erroneous assumed position of the sea-level; by all periodic and non-periodic fluctuations in the barometric height; by the difference in the temperature-correction between that due 50° Fahrenheit and the actual mean temperature of the two stations; and by the undetermined instrumental errors. Profiles, therefore, given by the direct use of the aneroid scale of feet, are but rough approximations, the principal source of error in which, in short intervals of time, is the temperature-correction above or below that due 50° Fahrenheit, which often amounts to many feet in the computed difference of altitudes between two stations very near each other horizontally. I give below the profile of a single day's march, as derived directly from the face-readings of the aneroid, and from computation, which shows pretty fairly the differences which we may expect in the gradients derived from the two methods.

Camp or station.	Altitude from aneroid face.	Altitude computed.	Difference.	Distance betw'n stations.	Grade per mile, from feet-scale.	Grade per mile, computed.	Difference per mile.
			Feet.	*Miles.*			
Camp 10	8720	8961.2	+241.2	0.000	......	......	......
1	8875	9118.9	243.9	0.203	761.0	769.0	+ 8.0
2	9025	9273.4	248.4	2.230	67.2	69.3	+ 2.1
3	9160	9403.2	243.2	.730	185.0	177.7	− 7.3
4	9200	9436.0	230.0	.753	53.1	43.6	− 9.5
5	9355	9602.1	246.1	2.393	64.8	69.4	+ 4.6
6	9530	9771.2	241.2	.839	208.3	201.3	− 7.0
7	8960	9180.2	220.2	1.633	349.0	361.9	+12.9
8	9245	9454.7	209.7	3.431	83.1	80.0	− 3.1
9	8675	8821.6	146.6	3.195	147.3	198.2	+50.9
10	8790	8949.9	159.9	.663	174.2	194.4	+20.2
11	9020	9207.0	187.0	.816	280.5	313.5	+33.0
12	9470	9666.1	196.1	1.220	368.8	376.3	+ 9.5
Camp 11	8520	8655.8	135.8	2.00	475.0	505.1	+30.1

For all ordinary purposes of map-construction, except where contours are wished with as close an approximation to accuracy as the means at our disposal will admit, the differences of altitude, as derived from the aneroid feet-scale, are sufficient upon the scale of our maps for the proper representation by conventional signs of the general relief of the country; but since continuous profiles were desired from which should be eliminated, as far as our knowledge and means would allow, the effects of periodic and non-periodic fluctuations in barometric height, it was necessary to carefully compute these observations by referring them to simultaneous observations at some fixed station whose altitude was known. In making these reductions, the first difficulty encountered arose from the fact that observations at the signal-stations were made at but few hours during the day, and, as a rule, at points of from 1,000 to 7,000 feet lower altitude than the mass of our aneroid observations, and although theoretically we could, by correcting for horary oscillation where this element was known, reduce our aneroid work to the mean of the day and refer these means to the observed means at the lower station, we were unable to determine the proper temperature to be used in the reductions, and where the difference of altitude was so considerable the corrections from this term of the barometric formula were very large, and instrumental errors also materially affected the resulting absolute heights when such an inconstant and variable instrument as the aneroid was referred to another of entirely different character, and the profiles were found so discordant that it required considerable ingenuity to correct them and make them agree with the camps whose altitudes were derived from series of cistern-barometer and thermometer observations, referred to synchronous observations at a lower station. To lessen the labor of computation, to reduce the aneroid to its proper position as simply an adjunct of the mercurial barometer and the effect of instrumental errors and worth of compensation to a minimum, the method of computation now in use was proposed by Lieutenant Hoxie, and perfected and used to advantage by myself and assistants for all of our last season's aneroid work. The method is as follows:

The altitudes of all camps are determined from a longer or shorter series of cistern-barometer, thermometer, and psychrometer observations, referred to synchronous observations at a lower station. The errors of the aneroid referred to the cistern at 32°. Fahrenheit are determined at each camp, and the mean error at two consecutive camps taken to correct all aneroid observations made between them, except where comparisons show that a sudden and great change in the error of the aneroid has occurred somewhere between the two camps, in which case the observations are rejected *in toto*, unless from our knowledge of the natural grades of the route we are enabled to locate the place in the profile where the change occurs, and to correct the observations before and after accordingly.

The aneroid, watch, and thermometer are read upon leaving camp in the morning, and at a number of intermediate stations *en route*, and the profile closed by taking one or more careful readings upon arrival at the next camp. The observations are then, after correction for instrumental error, reduced to the mean of the day by the correction for horary oscillation, and each station referred to the preceding one, the mean of the observed temperatures at the two stations being taken for the mean temperature of the stratum between them. Thus, since the aneroid was referred constantly to its own indications, instrumental errors enter the results with only a differential value. Beginning at camp, the successive differences of altitude are then added, each to the altitude of the station preceding, and the profile carried over to the next camp by successive steps. The difference in the altitude of this camp as brought over from the preceding camp by the aneroid differences and that determined from the series of cistern-barometer observations is the error to be distributed throughout the profile to make the two coincide It is evident that, in thus computing this profile, we assume that there has been no non-periodic or abnormal fluctuation in the height of the barometer during the interval of time the profile was being measured, whereas in fact the air is seldom or never in a position of equilibrium, and the barometer is continually varying in height. Should the barometer be *rising*, the difference of level between the two camps determined from this profile will be *too great* if we pass from a *higher* to a *lower* camp, and *too small* if we go from a *lower* to a *higher*, and *vice versa* if there be a *falling* barometer. In the first case, where the barometer is *rising*, the altitude of the second camp as determined from the profile will be too *low* by the amount in feet at that altitude of the abnormal oscillation, and *vice versa* when the barometer is *falling*, provided that the observations and computations are perfect.

In distributing the errors, I have supposed that the abnormal or non-periodic oscillation is approximately a right line during the few hours the party may be engaged in running the profile-line, and that the error from this source in the altitude of each station is directly proportional to the time, or let—

$E =$ the difference, in feet, in the altitude of camp 2, carried by aneroid from camp 1 and that computed from synchronous observations of cistern-barometers;

$T =$ entire interval of time, in minutes, between instant of leaving camp 1 and arriving in camp 2;

l = interval, in minutes, between leaving camp 1 and arriving at any profile-station;
C = correction, in feet, to be applied to the altitude of that station;
Then—

$$C = \frac{l}{T} E$$

In unimportant profiles, it is sufficiently accurate for our purposes to divide the errors equally between the various stations.

Respectfully submitted.

W. L. MARSHALL,
First Lieut. Engineers, in charge of Meteorological Branch.

First Lieut. G. M. WHEELER,
Corps of Engineers.

FORM I.—FOR THE GENERAL RECORD.

Party No. 2, division No. 2.—Book 66.—B. W. Bates, Observer.

CAMP No. 33, ON THE RIO SAPELLO, NEW MEXICO.

Date.	Standard cistern-barometer No. 1989. Hour.	Att. ther. (+ 1°.1 er.)	Reading.	Error, (.005.)	Reduction to 32° F.	Barometer at 32°.	Cist.-bar. No. 1767. Att. ther.	Reading.	Aneroids. No. 528—reading.	Att. ther.	No. O—reading.	Att. ther.	No. —reading.	Att. ther.	Thermometers. No. 1767. Dry	Wt.	No. —. Mx.	Mn.	Clouds. Amount.	Name.	Direct'n of upper clo'ds	Wind. Direction.	Force.	Rain or snow. Began.	Ended.	Inches.	Remarks.
1874. Sept. 29	3 p. m.	77.1	23.968	+.005	−.104	23.869	77.0	23.956			23.710	None			77.0	52.0			1	Cumulus	0	S. W.	0.5				
Sept. 29	6 p. m.	66.1	.932	+.005	−.081	.856	63.5	.932	23.600	None	.690	None			63.5	46.0			4	Cirro-str.	0	S. W.	0.5				
Sept. 29	9 p. m.	46.6	.940	+.005	−.039	.906	46.0	.952	.640	None	.800	None			46.0	39.0			5	Cirro-str.	0	0	0.0				
Sept. 30	6 a. m.	46.1	.958	+.005	−.038	.925	46.0	.952	.610	None	.860	None			46.0	39.5			8	Cirro-str.	N. E.	S. W.	0.0				Light dew.

CAMP No. 34, ARROYO DE LOS PECOS, NEW MEXICO.

Date.	Hour.	Att. ther. (+ 1°.1 er.)	Reading.	Error, (.005.)	Reduction to 32° F.	Barometer at 32°.	Cist.-bar. Att. ther.	Reading.	No. 528—reading.	Att. ther.	No. O—reading.	Att. ther.	No. —reading.	Att. ther.	Dry	Wt.	Mx.	Mn.	Amount.	Name.	Direct'n of upper clo'ds	Direction.	Force.	Began.	Ended.	Inches.	Remarks.
Sept. 30	3 p. m.	77.1	23.979	+.005	−.104	23.880	77.0	23.966	23.540	None	23.710	None			77.0	49.0			2	Cirrus		S. W.	1.0				Alkaline water.
Sept. 30	6 p. m.	64.1	.945	+.005	−.076	.874	63.0	.941	.540	None	.720	None			63.0	45.0			4	Cirro-str.		S. W.	1.0				
Sept. 30	9 p. m.	55.6	.950	+.005	−.058	.897	55.0	.937	.540	None	.710	None			55.0	43.0			0	0		S. W.	1.0				
Oct. 1	6 a. m.	38.1	.878	+.005	−.021	.862	38.0	.880	.490	None	.760	None			38.0	34.0			0	0		E.	1.0				

CAMP No. 35, BERNAL ARROYO, NEW MEXICO.

Date.	Hour.	Att. ther. (+ 1°.1 er.)	Reading.	Error, (.005.)	Reduction to 32° F.	Barometer at 32°.	Cist.-bar. Att. ther.	Reading.	No. 528—reading.	Att. ther.	No. O—reading.	Att. ther.	No. —reading.	Att. ther.	Dry	Wt.	Mx.	Mn.	Amount.	Name.	Direct'n of upper clo'ds	Direction.	Force.	Began.	Ended.	Inches.	Remarks.
Oct. 1	3 p. m.	81.1	24.144					24.158			23.920				81.0	50.0			1	Cumulus.		N.	0.5				Aneroid 528 with side-party.
Oct. 1	6 p. m.	64.6	.154					.122			.920				63.5	46.0			1	Stratus		N.	1.0				Att'd ther. barom. 1767 broken.
Oct. 1	9 p. m.	50.1	.138					.148			.940				49.5	39.5			0	0		N. W.	1.0				
Oct. 2	6 a. m.	44.1	.117					.109	24.210		24.020				43.0	36.0			1	Nimbus		S. W.	1.0				Use air-temperature for reducing.

FORM II.—TRANSCRIPT FROM FORM I.—METEOR

Party No. 2, division No. 2.—Recorded in

CAMP No. 33.—ON THE

Date.	Hour.	Standard cistern-barometer No. 1989, (error, + 0.005.)						Cistern-barometer No. 1767.					Aneroid No. 528.		
		Att'd ther. corr'd, (error, + 1.1.)	Reading.	Correct for error and red. to 32°.	Barometer at 32°.	Horary correction.	Baromet'r reduced.	Att'd ther.	Error.	Reading.	Error.		Att'd ther.	Reading.	Error.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sept. 29	3 p. m.	77. 1	23. 968	—. 099	23. 869	+. 038	23. 907	77. 0	+ 0. 1	23. 956	+. 012	2′	......	......	......
Sept. 29	6 p. m.	66. 1	. 932	—. 076	. 856	+. 026	. 882	63. 5	+ 2. 6	. 932	—. 000	....	None	23. 600	+. 256
Sept. 29	9 p. m.	46. 6	. 940	—. 034	. 906	—. 001	. 905	46. 0	+ 0. 6	. 952	—. 012	....	None	. 640	+. 266
Sept. 30	6 a. m.	46. 1	. 958	—. 033	. 925	—. 034	. 891	46. 0	+ 0. 1	. 952	+. 006	....	None	. 610	+. 315
Mean	....	59. 0	23. 950	......	23. 889	......	23. 896	58. 1	......	23. 948	+. 002	....	None	23. 617	+. 279
CAMP No. 34.—ARROYO															
Sept. 30	3 p. m.	77. 1	23. 979	—. 099	23. 880	+. 038	23. 918	77. 0	+ 0. 1	23. 966	+. 013	....	None	23. 540	+. 340
Sept. 30	6 p. m.	64. 1	. 945	—. 071	. 874	+. 026	. 900	63. 0	+ 1. 1	. 941	+. 004	....	None	. 540	+ ·334
Sept. 30	9 p. m.	55. 6	. 950	—. 053	. 897	—. 001	. 896	55. 0	+ 0. 6	. 937	+. 013	....	None	. 540	+. 357
Oct. 1	6 a. m.	38. 1	. 878	—. 016	. 862	—. 034	. 828	38. 0	+ 0. 1	. 880	—. 002	....	None	. 490	+. 372
Mean	....	58. 7	23. 938	......	23. 878	......	23. 886	58. 2	......	23. 931	+. 007	....	None	23. 528	+. 350
CAMP No. 35.—BERNAL															
*Oct. 1	3 p. m.	81. 1	24. 144	—. 108	24. 036	+. 038	24. 074	....	......	24. 158	—. 014	....	None	(†)	(†)
*Oct. 1	6 p. m.	64. 6	. 154	—. 172	. 082	+. 026	. 108	....	......	. 122	+. 032	....	None	......	......
*Oct. 1	9 p. m.	50. 1	. 138	—. 041	. 097	—. 001	. 096	....	......	. 148	—. 010	....	None	......	......
*Oct. 2	6 a. m.	44. 1	. 117	—. 029	. 088	—. 034	. 054	....	......	. 109	+. 008	....	None	24. 210	—. 122
Mean	....	60. 0	24. 138	......	24. 076	......	24. 083	....	......	24. 134	+. 004	....	None	24. 210	—. 122
CAMP No. 36.—ON THE															
Oct. 2	3 p. m.	78. 6	23. 664	—. 100	23. 564	+. 038	23. 602	....	......	23. 645	+. 019	....	......	(†)	(†)
Oct. 2	6 p. m.	67. 6	. 628	—. 077	. 551	+. 026	. 577	....	......	. 611	+. 017	....	......	......	......
Oct. 2	9 p. m.	56. 6	. 621	—. 054	. 567	—. 001	. 566	....	......	. 629	—. 008	....	......	......	......
Oct. 3	6 a. m.	53. 6	. 658	—. 048	. 610	—. 034	. 576	....	......	. 645	+. 013	....	......	......	......
Mean	....	64. 1	23. 643	......	23. 573	......	23. 580	....	......	23. 633	+. 010	....	......	......	......

* Aneroid 528 on side-party. Attached thermometer of barometer 1767 out of order.

NOTE.—Fill out, in the field, columns Nos. 1, 2, 3, 4, 9, 11, 14, 15, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, and 28. lines between them. On the first of these lines record in *red ink* the means of the preceding set of of remarks [which is omitted in the above table for want of space] concerning the preceding place of the set of observations at that locality. When two cistern-barometers are read together, enter the the standard barometer. The error of the other barometer is to be obtained by comparison with the *thermometer* " corrected for error. The aneroid errors are to be determined by comparison with the and *minus* when greater.

OLOGICAL OBSERVATIONS IN THE FIELD, 1874.

Book No. 66.—Theo. V. Brown, Computer.

SAPELLO RIVER, NEW MEXICO.

Aneroid No. O. † Att'd ther.	Aneroid No. O. † Reading.	Aneroid No. O. † Error.	Aneroid No. —. Att'd ther.	Aneroid No. —. Reading.	Aneroid No. —. Error.	Clouds. Amount.	Clouds. Name.	Clouds. Direction of upper clouds.	Rain or snow. Began.	Rain or snow. Ended.	Rain or snow. Inches.	Wind. Direction.	Wind. Velocity, (10 max.)	Thermometers. No. —. Max.	Thermometers. No. —. Min.	Thermometers. No. —. Dry bulb.	Thermometers. No. —. Wet bulb.	Thermometers. No. —. Differ-ence.	Force of vapor.	Relative humidity.
14	15	16	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
None.	23. 710	+. 159	....	....	....	1	Cum ..	0	....	....	....	SW	0. 5	....	....	77. 0	52. 0	25. 0	. 199	. 215
None.	. 690	+. 166	....	....	....	4	Cir.-st.	0	....	....	....	SW	0. 5	....	....	63. 5	46. 0	17. 5	. 176	. 301
None.	. 800	+. 106	....	....	....	5	Cir.-st	0	....	....	....	0	0. 0	....	....	46. 0	39. 0	7. 0	. 174	. 561
None.	. 860	+. 065	....	....	....	8	Cir.-st.	NE	....	....	....	SW	0. 5	....	....	46. 0	39. 5	6. 5	. 182	. 586
None.	23. 765	+. 124	....	....	....	....	....	....	....	....	....	....	....	....	....	58. 1	44. 1	14. 0	. 183	. 416

DE LOS PECOS, NEW MEXICO.

None	23. 710	+. 170	....	....	....	2	Cirrus.	0	....	....	....	SW	1. 0	..	....	77. 0	49. 0	28. 0	. 162	. 175
None	. 720	+. 154	....	....	....	4	Cir.-st.	0	....	....	....	SW	1. 0	....	....	63. 0	45. 0	18. 0	. 165	. 288
None	. 710	+. 187	....	....	....	0	0	0	...	....	....	SW	1. 0	....	....	55. 0	43. 0	12. 0	. 177	. 410
None	. 760	+. 102	....	....	....	0	0	0	....	....	....	E	1. 0	....	....	38. 0	34. 0	4. 0	. 157	. 686
None	23. 725	+. 153	....	....	....	....	....	....	....	....	....	....	....	....	....	58. 2	42. 7	15. 5	. 165	. 390

ARROYO, NEW MEXICO.

None	23. 920	+. 116	....	....	....	1	Cum ..	0	....	....	....	N	0. 8	....	....	81. 0	50. 0	31. 0	. 160	. 151
None	. 920	+. 162	....	....	....	1	Stratus	0	....	....	....	N	1. 0	....	....	63. 5	46. 0	17. 5	. 176	. 301
None	. 940	+. 157	....	....	....	0	0	0	....	....	....	NW	1. 0	....	....	49. 5	39. 5	10. 0	. 159	. 448
None	24. 020	+. 068	....	....	....	1	Stratus	0	....	....	....	SW	1. 0	....	....	43. 0	36. 0	7. 0	. 151	. 543
None	23. 950	+. 126	....	....	....	....	....	....	....	....	....	....	....	....	....	59. 2	42. 9	16. 3	. 162	. 361

PECOS RIVER, NEW MEXICO.

None	23. 385	+. 179	....	....	....	4	Cu.-st.	NE	....	....	....	SE	1. 0	....	....	78. 5	53. 5	25. 0	. 214	. 216
None	. 390	+. 161	....	....	....	10	Nimb..	0	....	....	....	SE	0. 5	....	....	67. 0	51. 0	16. 0	. 231	. 349
None	. 420	+. 147	....	....	....	8	Cum ..	0	....	....	....	SE	3. 0	....	....	56. 0	45. 5	10. 5	. 209	. 465
None	. 490	+. 120	....	....	...	6	Cu.-st.	0	....	....	....	NE	1. 0	....	....	53. 5	48. 0	5. 5	. 274	. 666
......	23. 421	+. 152	....	....	....	....	....	....	....	....	....	....	....	....	....	63. 8	49. 5	14. 3	. 232	. 424

Hereafter air-temperature used in reducing to 32° F. † With side-party.

Separate the observations at each place from those at the next following place by leaving two or more observations. On the lines next following record whatever may have been crowded out of the column observation. Describe each locality in full, using, if necessary, the entire line immediately preceding reading of that one which is the more reliable, or which is more habitually in the party, in column 4, as reading of the standard, corrected for instrumental error only, and with the reading of its "*Attached* "*Standard barometer at* 32° *F.*" The "error" is *plus* when the reading is less than that of the standard,

Form III.—Aneroid readings.

No. of observation.	Hour.	Aneroid. No.	Aneroid. Reading.	Cistern No. 1735, reading 32° F.	Error of aneroid.	Temperature.	Weather.	Aneroid in feet.	Zero of feet-scale set at inches.	Date: August 24, 1874. From camp No. 8 to camp No. 9. Party: Main; Lieutenant Wheeler, observer.
Camp..	6. 00 a. m.	1719	22. 35	22. 715	+365	48. 38	Cumulus..........	7610	29. 65	At Conejos, Colo.
1	8. 15 a. m.	1719	. 35	....	Adopt. +376.	50. 5	Cumulus..........	7610	29. 65	Ford of Conejos Creek, Guadaloupe.
2	10. 00 a. m.	1719	21. 965	....		74. 5	Cumulus..........	8045	29. 65	First ascent of mesa.
3	12. 20 p. m.	1719	. 010	....		69. 6	Cumulus and wind.	9260	29. 65	Saddle near Prospect Peak.
4	1. 00 p. m.	1719	20. 84	....		70. 2	Nimbus and wind	9455	29. 65	Prospect Peak, Colo.
5	2. 00 p. m.	1719	. 81	....		68. 8	Nimbus and wind	9500	29. 65	Do.
6	2. 30 p. m.	1719	. 835	....		66. 3	Rain..............	9460	29. 65	Do.
7	3. 00 p. m.	1719	. 835	....		62. 2	Rain..............	9460	29. 65	Do.
8	....	.....	....	....		....	....	....	....	
9	....	.....	....	....		....	....	....	....	
10	....	.....	....	....		....	....	....	....	
11	....	.....	....	....		....	....	....	....	
12	....	.....	....	....		....	....	....	....	
13	....	.....	....	....		....	....	....	....	
Camp..	8. 00 p. m.	1719	21. 93	22. 318	+388	54. 2	Rain..............	8090	29. 65	On Conejos Creek, Colo.

NOTE.—Give locality of camp or station, with State or Territory in which situated. Take readings at *divides*, *crossings of streams*, *towns*, *ranches*, *settlements*, *mountain-summits*, *&c.*, and, in general, at points which can be located without the aid of the topographer.

Form IV.—Aneroid and Odometer.

Date, August 16, 1874.—*Party* 2, *division* 1. ——, *recorder. From camp No.* 10, *on North Fork of Costilla Creek, to camp No.* 11, *on Rio Colorado, N. Mex.*

Station.	Hour.	Aneroid.		Temperature.	Cistern-barom., (error −0.020.)		Error of aneroid.	Station.	Odometer.			Aneroid in feet	Zero set at inches.	Remarks.
		No.	Reading.		Reading.	Att. T.			Reading.	Per mile.	Miles.			
						°							″	
Camp No. 10	6. 00 a. m.	1716	21. 830	54. 8	21. 876	44	−. 005	Camp No. 10	000	570	. 000	8720	29. 99	North Fork Costilla Creek.
Station ... 1	7. 35 a. m.	......	. 700	61. 5	....	....	Determined from means of comparisons at camp 10.	1	116	570	. 203	8875	29. 99	
2	8. 22 a. m.	......	. 575	71. 3	....	....		2	1444	570	2. 230	9025	29. 99	
3	8. 50 a. m.	......	. 475	81. 2	....	....		3	1865	570	. 739	9160	29. 99	
4	9. 12 a. m.	......	. 450	80. 8	....	....		4	2294	570	. 753	9200	29. 99	
5	10. 00 a. m.	......	. 325	78. 8	....	....		5	3658	570	2. 393	9355	29. 99	
6	11. 10 a. m.	......	. 200	82. 8	....	....		6	4136	570	. 839	9530	29. 99	Divide.
7	12. 20 p. m.	......	. 625	82. 8	....	....		7	5067	570	1. 633	8960	29. 99	
8	2. 15 p. m.	......	. 400	64. 8	....	....		8	7023	570	3. 431	9245	29. 99	Second divide.
9	3. 47 p. m.	......	. 875	70. 8	....	....		9	8844	570	3. 195	8675	29. 99	
10	4. 05 p. m.	......	. 775	70. 8	....	....		10	9222	570	. 663	8790	29. 99	
11	4. 30 p. m.	......	. 575	69. 3	....	....		11	9687	570	. 816	9020	29. 99	
12	5. 05 p. m.	......	. 225	70. 8	....	....		12	10460	570	1. 220	9470	29. 99	
13	....	......	....	......	....	....		13	......	......	......	......	......	
14	....	......	....	......	....	....		14	......	......	......	......	......	
15	....	......	....	......	....	....		15	......	......	......	......	......	
16	....	......	....	......	....	....		16	......	......	......	......	......	
17	....	......	....	......	....	....		17	......	......	......	......	......	
18	....	......	....	......	....	....		18	......	......	......	......	......	
19	....	......	....	......	....	....		19	......	......	......	......	......	
20	....	......	....	......	....	....		20	......	......	......	......	......	
21	....	......	....	......	....	....		21	......	......	......	......	......	
22	....	......	....	......	....	....		22	......	......	......	......	......	
23	....	......	....	......	....	....		23	......	......	......	......	......	
24	....	......	....	......	....	....		24	......	......	......	......	......	
25	....	......	....	......	....	....		25	......	......	......	......	......	
Camp No. 11	5. 55 p. m.	......	22. 000	......	....	....		Camp No. 11	11629	......	. 200	8520	29. 99	Rio Colorado, New Mexico, tributary to Rio Grande.

Note.—Compare aneroid with cistern at *all camps*. Enter reading of cistern in column headed "Cistern-barom."

FORM V.

Party No. 2, division No. 1.—Book No. 8.—Date, August 16, 1874.—Camp No. 10 to No. 11.

Station.	Hour.	Distance in miles.	ANEROID PROFILES. Aneroid, (Casella.) No.	Aneroid, (Casella.) Reading.	Cistern-barometer No. 1989, (error − 0″.020.) Reading.	Cistern-barometer Attached thermometer.	Cistern-barometer Barometer at 32°.	Correct for error of aneroid.	Correct for horary oscillation.	Total correction.	COMPUTATIONS. Corrected readings.	Temperature.	t+t′	$D_{,}$ (h H)	First app. difference of altitude.	$D_{,,}$ (t+t′)	Second app. difference of altitude.	Altitude.	Distribution of error.	Altitude above sea-level.	Remarks.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Camp No. 10	6.00 a. m.	.000	1716	21.830	21.876	44.0	21.825	−0.005	−.012	−.017	21.813	54.8	.....	20453.2	Altitude by cistern			8961.2	00.0	8961.2	On North Fork Costilla Creek, New Mexico.
1	7.35 a. m.	.203	....	.700					−.009	−.014	.686	61.5	116.3	20300.0	+153.2	+ 8.9	+ 162.1	9123.3	− 4.4	9118.9	
2	8.22 a. m.	2.230	....	.575					−.004	−.009	.566	71.3	132.8	20154.4	+145.6	+11.1	+ 156.7	9280.0	− 6.6	9273.4	
3	8.50 a. m.	.739	....	.475					−.002	−.007	.468	81.3	152.6	20035.0	+119.4	+11.7	+ 131.1	9411.1	− 7.9	9403.2	
4	9.12 a. m.	.753	....	.450					−.002	−.007	.443	80.8	162.1	20004.5	+ 30.5	+ 3.3	+ 33.8	9444.9	− 8.9	9436.0	
5	10.00 a. m.	2.393	....	.325					−.001	−.006	.319	78.8	159.6	19852.3	+152.2	+16.2	+ 168.4	9613.3	−11.2	9602.1	
6	11.10 a. m.	.839	....	.200					−.002	−.007	.193	82.8	161.6	19696.9	+155.4	+16.9	+ 172.3	9785.6	−14.4	9771.2	Divide between Costilla Creek and Rito Colorado.
7	12.20 p. m.	1.633	....	.625					+.004	−.001	.624	82.8	165.6	20225.0	−528.1	−59.6	− 587.7	9197.9	−17.7	9180.2	
8	2.15 p. m.	3.431	....	.400					+.019	+.014	.414	64.8	147.6	19969.0	+256.0	+23.8	+ 279.8	9477.7	−23.0	9454.7	
9	3.47 p. m.	3.195	....	.875					+.025	+.020	.895	70.8	135.6	20551.6	−582.6	−46.2	− 628.8	8848.9	−27.3	8821.6	
10	4.05 p. m.	.663	....	.775					+.026	+.021	.796	70.8	141.6	20432.7	+118.9	+10.3	+ 129.2	8978.1	−28.2	8949.9	
11	4.30 p. m.	.816	....	.575					+.029	+.024	.599	69.3	140.1	20194.6	+238.1	+20.1	+ 258.2	9236.3	−29.3	9207.0	
12	5.05 p. m.	1.220	....	21.225					+.032	+.027	21.252	70.8	140.1	19769.7	+424.9	+35.9	+ 460.8	9697.1	−31.0	9666.1	
13																					
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Camp No. 11	5.55 p. m.	.200	....	22.000					+.024	+.019	22.019	69.0	139.8	20699.4	−929.7	−78.3	−1008.0	8689.1	−33.3	8655.8	On Rito Colorado, New Mexico, tributary to Rio Grande.
Altitude of camp 11 by series of cistern-barometer observations																		8655.8			
Error in aneroid profile																		− 33.3			

NOTE.—Form to be filled and forwarded monthly to headquarters. Fill out columns 1, 2, 3, 4, and 12 from the "Aneroid readings" and "Aneroid and odometer" books; columns 5, 6, and 12 from meteorological book.

In column of "Remarks" the locality of the camp or station, with the name of the State or Territory in which situated, will be entered. Locality cannot be too explicitly given.

APPENDIX G 1.

REPORT ON THE GEOLOGY OF THAT PART OF NORTHWESTERN NEW MEXICO EXAMINED DURING THE FIELD-SEASON OF 1874, BY E. D. COPE, PALEONTOLOGIST AND GEOLOGIST.

PHILADELPHIA, *June* 11, 1875.

SIR: The present report includes the results of the investigation of the stratigraphic geology of the part of New Mexico to which you assigned me for the field-season of 1874. The ground covered embraces the eastern slope of the Rocky Mountains from Pueblo to the Sangre de Cristo Pass, both sides of the Rio Grande Valley from that point to Algodones, and the Sierra Madre range and the country for fifty miles to the westward of it from the latitude of Tierra Amarilla to that of the road from Santa Fé to Fort Wingate.

Little of novelty has been added from the two first-named regions, as they have been previously traversed by competent geologists; but the last-named area has remained up to the present time almost unknown. The analysis of the structure of the Sierra Madre range is believed to indicate that its elevation took place near the close of the period known as Cretaceous No. 4, and that the elevating force was more powerful at its southern extremity in New Mexico than along the middle portion of its line. Another important discovery is the lacustrine character of the Triassic beds, which form a part of the axis of the range, indicating the existence of extensive areas of dry land at that period, of which no portion is remaining in the region examined by me, but which may be supposed to be represented by the Paleozoic beds farther south and west. A third important point is the determination that the plateau drained by the eastern tributaries of the San Juan River is composed of the sediment of an extensive lake of Eocene age, which was probably at one time of great extent, but whose deposits have been greatly reduced in extent through erosion. The boundaries of this lake to the west and south were determined.

It is believed that additional light has been thrown on the question of the age of the Galisteo sandstone, and that its paleontology has decided definitely that of the Santa Fé marls. The first fossils discovered in the "Trias" of the Rocky Mountains have enabled me to reach more definite conclusions as to its position in the scale of periods.

I remain, with regard,

E. D. COPE,
Geologist and Paleontologist.

Lieut. GEORGE M. WHEELER,
Corps of Engineers.

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INTRODUCTORY.

The route pursued by the party to whom the duty of determining the geognostic character of the country was assigned is the following:

Leaving Pueblo, it took the main road southward for about thirty miles, to Howard's, on the Huerfano Creek. From this point its course was southwest, via Badito, and across the mountain-range at the Sangre de Cristo Pass to Fort Garland, in the valley of the Rio Grande. We then turned toward the south and followed the road on the east side of the Rio Grande one hundred and twenty-five miles, to Santa Fé. Side-excursions were made to the east a short distance south of the Picoris Mountains, and the west to El Rito, across the country, between the Rio Grande and the Rio Chama; also, to the Jemez Mountains. The geological examinations were extended to the Zandia Mountains, forty miles south of Santa Fé.

The exploration to the west of the Rio Grande left that river at the mouth of the Rio Chama, and followed its course as far as the mouth of the Cañon Canjelon, a distance of about thirty miles. The direction then pursued was north and northwest for thirty miles, reaching the Chama River again at Los Ojos. From this point the party followed

the strike of the formations of the country to the south, on the west side of the Gallinas Mountains, reaching the Rio Puerco at a point fifty miles southwest from Los Ojos. Considerable time was occupied in this expedition, side-trips being continually made east and west of the line, the latter as far as the Alto del Uta, forty miles west of the Gallinas Mountains.

The same route was traversed in returning as far as the Rio Chama and the town of Tierra Amarilla. From this point, the expedition took the direct course across the San Juan Mountains to Conejos, and across the Rio Grande Valley to Fort Garland. The route from this point to Pueblo was the same as that followed on the outward trip.

As is now well known, the ranges composing the Rocky Mountains form a series of *échelons*, which have a generally north and south course, and descend to the plain at their southern extremities. The result is that when this arrangement prevails the trend of the entire mass of ranges is not identical with that of the constituent ranges, but is southwest and northeast. Thus the Front range, which bounds the plains continuously for two hundred and fifty miles, disappears in the Shyenne Mountains, near to Pike's Peak. The second range, or Wet Mountains, disappears at the entrance to the Sangre de Cristo Pass, after having culminated in the Greenhorn Mountain. The third, or Sangre de Cristo range, extends one hundred miles south of the pass, and sinks into the plains not far southeast of Santa Fé. The fourth range bounds the valley of the Rio Grande on the west, and has received various names in its different extensions. It is the San Juan, Navajo, Gallinas, and Nacimiento Mountains of the present survey. These are sometimes known under the collective term Sierra Madre, and they exhibit a reduction in elevation as compared with their northern continuation in Colorado; a reduction which continues to the southward until, in Central New Mexico, they no longer constitute a continuous range.

It is seen therefore that the expedition passed round the southern extremity of the Wet Mountain *échelon*, and crossed the two axes of the Sangre de Cristo and Sierra Madre. Observation therefore extended to the structure of the western border of the Mississippi drainage, to the entire width of the drainage-area of the Rio Grande, and to the eastern portions of the area mostly drained by the Great Colorado. The subject will therefore be considered under three heads, viz: the eastern slope of the Rocky ranges; the Rio Grande Valley; and the western slope of the Sierra Madre.

CHAPTER I.

THE EASTERN SLOPE OF THE ROCKY MOUNTAINS.

The Rocky Mountains axes are well known to be composed of a feldspar-porphyry, where not exceptionally igneous and intrusive. These axes were forced through superincumbent sedimentary strata, the remnants of which now rest upon their flanks. Those of the sedimentary strata which extended across the region now occupied by the mountain-ranges were necessarily lifted to an almost or quite vertical position, in which they now remain. Other beds, deposited after the commencement of the process of the elevation and before its conclusion, were necessarily raised so as to lie more obliquely against the sides of the axes or of the older sedimentary beds; while strata deposited after the close of the process of elevation extend to and rest upon the slopes of the ranges nearly as they were originally deposited, in a horizontal position.

At Manitou, near Colorado Springs, the porphyritic granite is immediately covered by sandstones and limestones of Silurian age, of 70 feet in thickness, mostly of a reddish color. This formation is succeeded in ascending order by 279 feet of gray, purplish, and yellow limestone supposed to be of Carboniferous age. Above this is a series of red or variegated sandstones, often containing conglomerate beds, and often very massive, of 1,200 to 1,500 feet in thickness. No fossils have yet been found in this horizon, so that its age has been conjecturally called Triassic. This is followed by about 31 feet of calcareous shales, with thin beds of sandstones, in which fossils of Jurassic age occur in other localities. Above these Jurassic beds is a stratum of white gypsum of 57 feet in depth. It is below the Cretaceous No. 1, and is sometimes included in the Jurassic. (See Dr. Peale, Report of the U. S. Geol. Surv. of the Territories, 1873, p. 198.) From this point upward the members of the Cretaceous may be traced. After an interval of 60 feet of shales and soft sandstones, the gypsum is followed by a bed of white or pale massive sandstone of 200 or a few more feet in thickness. This is Cretaceous No. 1, or the Dakota group, a very important base-line in estimating the position of other strata in New Mexico. Its hardness and consequent resistance to erosive forces have left to it a prominent position as the axis of the first range of foot-hills along the mountains for very great distances. It is followed in the ascending series by soft and dark-colored shales, usually rich in invertebrate fossils, which are known as the Benton group, or No. 2. The Niobrara group (No. 3) consists usually of impure limestone either of a siliceous or argillaceous character. It forms the crest of the second and lower line of foot-hills, and is often highly fossiliferous; common species being *Ostrea congesta* and *Inoceramus problematicus*. The following beds are again

of a soft and shaly character, frequently of a dark color, and resembling those of No. 2; these are the Fort Pierre group No. 4. The brown and yellow beds of No. 5 (Fox Hills group) lie upon these. They are arenaceous and of various degrees of hardness, and frequently heavily bedded.

Occupying a horizontal position on Cretaceous No. 5, there is found in Central Colorado a series of yellow and brown arenaceous mud-beds of estuary and fresh-water origin, which contain beds of lignite and abundant remains of the land-plants and animals of the surrounding continent. These are the Fort Union group of Hayden, or Cretaceous No. 6 of the writer. The succeeding formations are lacustrine and Tertiary; the earliest, or Eocene, appearing on the western side of the mountains, while on the eastern side this formation is omitted, the Miocene lying immediately on the Cretaceous.

The hills bounding the valley of the Arkansas at Pueblo consist of shales of Cretaceous No. 4. When long exposed they become white and hard, but when first exposed are usually of a dark color. At Pueblo I observed scales of physoclystous fishes (*? Beryx*) with *Inoceramus* and plant-remains. Similar remains have been drawn up from well-shafts sunk several miles south of Pueblo, and appear in the sides of ravines near the Saint Charles Creek. The bluffs of the Saint Charles are 150 feet in height, and are composed of the same material, which on exposure is light-colored, and splits up into large flakes, which exhibit conchoidal fractures, and a hard consistence.

Farther southward, bluffy ledges extend at right angles to the mountain-axis, facing the south. On the south side of the Greenhorn they are overlaid by a soft buff sandstone which forms the high ground, dipping 30° southeast. This is perhaps to be referred to Cretaceous No. 5. The beds of No. 4 constitute the surface of the country for a distance of from six to fifteen miles from the mountains as far south as the Grenaros Creek. One mile south of this point, the soft rusty and gray sandstone of No. 5 caps the bluffs to a height of 150 feet; No. 4 disappearing beneath it with a southerly dip. Twelve miles north of Howard's, some bluffs to the west of the road face the east; the upper 40 feet is of yellowish shade, the lower of a bluish color, 40 feet to the base. At the line of junction of these colors, the rock is filled with *Ostrea congesta* and fragments of *Haploscapha*. At Howard's, on the Huerfano, the mesas are composed of No. 4, lying nearly horizontal in shaly argillaceous layers of a muddy color. The mesas are 50 feet high; wells sunk 50 feet from their foot-level exposed the same rock of a darker color to blackish, containing *Ammonites*, *Baculites*, and *Inoceramus*. A boring of 30 feet from the bottom of the well brought up the same material.

The tract of country between Pueblo and the Huerfano is elevated, and has an arid appearance, owing to the scarcity of water. The valleys of the streams flowing from the westward are exceptions to this statement, and toward the foot of the mountains beautiful meadows and farms can be seen from the line of the road.

Turning toward the mountains at Howard's, we proceed up the valley of the Huerfano, with nearly horizontal beds of the buff sandstones of No. 5 exhibited on the south side of the creek, to near Badito, near the point of extinction of the Wet Mountains. Here the beds are observed to rise to the mountain-axis, and are displayed in the following order, beginning with the lowest: The red beds display their brilliant color high up, and are overlaid by the bed of snow-white gypsum, usually referred to the Jurassic. Above this we have the sandstone of Cretaceous No. 1, constituting an important topographical feature of the mountain-slope. The valley below is doubtless excavated from No. 2, while outside of it a low hog-back of siliceous brown limestone of Cretaceous No. 3 runs parallel to the range near the village. The light and dark shales of No. 4 form the ledges outside of and above No. 3, constituting the faces of the bluffs on the north side of the Huerfano Valley. All of these beds lie at an angle of 45° east at the line of strike; but the soft sandstone, which caps No. 4, and which I have called No. 5, has been little disturbed. From the hog-back exposure of No. 3, I obtained twelve species of fossils, as follows: *Ostrea congesta*; *Ostrea* near *larva*, Mort.; a shell with a ribbed disk; *Inoceramus*; a *Pecten*; *Ptychodus Whippleyi*, Marcou; *Ptychodus papillosus*, Cope; *Galeocerdo Edgertonii*, Agas.; *Otodus*, two species; *Lamna Texana*, Roem.; *Lamna*, No. 2; *Oxyrhina*, sp.

The sandstone bed of Cretaceous No. 1 forms the slope of the southern extremity of the Wet Mountains. It dips east, south, and west as the road passes over the ridge and enters the valley, separating that range from the Sangre de Cristo Mountains, which is known as the Huerfano Park. On the west side of the Wet Mountains the sedimentary rocks repeat with reversed dip the arrangement seen on the eastern flank. The red beds and the gypsum are conspicuous landmarks high above the valley, while the sandstones of No. 1 are seen to be immediately overlaid by light-colored shales, which greatly resemble those of No. 4, but which are as much like those of No. 2. These beds and those below them through the red Trias, are exposed along the road at one point of its passage of this anticlinal. The plain of the Huerfano Park is occupied by mesas of a soft yellowish rock of Cretaceous age, but of which of the subdivisions of the latter I did not ascertain.

The eastern slope of the Sangre de Cristo Mountains, as well as the foot-hills traversed

in reaching its base, is composed of the sandstone of Cretaceous No. 1, which first exhibits southern dips, but on the flanks of the mountain eastern dips. At various points below and during the ascent, trap-dikes rise above the surrounding level, sometimes to considerable elevations, having a southwest and northeast strike. Higher up igneous intrusions appear on a larger scale, and the ground is covered with fragments of a fine-grained siliceous mineral, apparently rhyolite. Several large mountains on the left and right of the road appear to be composed of this igneous product. On approaching the pass, the road traverses the red sandstone. The highest point includes two adjacent hills; the eastern measuring by the aneroid 9,460 feet, the western 9,425 feet in elevation. The former of these is composed of the red sandstone; the other, in its eastern half, of the same formation, which is here thin-bedded, but in its western half, of a light-colored intrusive dolerite, including crystals of a black mineral.

CHAPTER II.

THE VALLEY OF THE RIO GRANDE TO SANTA FÉ.

On the west side of the Sangre de Cristo Pass, the sandstone beds dip west 30° to 60°. Three miles west the sandstone is vertical, and a little beyond is a bed of Carboniferous limestone, also nearly vertical. From a locality in this region, General August Kautz, then in command at Fort Garland, procured a series of Carboniferous invertebrate fossils, which he kindly presented to the survey, and which have not been identified.

From the same region Major Hartz procured from a sandstone rock the impression of a large Goniatite which was added to the paleontological collection. Through his attention, along the upper waters of Sangre de Cristo Creek, near the locality of the Carboniferous sandstone, a bed of black shale is followed by a greenish sandstone, both dipping 15° east. Near this point the hill is covered with fragments of rhyolite, with concentric reddish stains, like that which has been described from Eastern Nevada. A mile westward the dip of the sandstone is reversed, and for a few miles beyond it exhibits contrary dips. The road gradually descends, and eight or ten miles west of the pass we come upon the real axis of the range, the red feldspar-porphyry.

I found settlers rooting out carefully a white-flowered *Astragalus*-like plant, with radical leaves of a light green, with a silky pubescence, on the ground of its being poisonous to cattle and horses. On my arrival at Fort Garland, I found these statements confirmed by Dr. Moffatt, post-surgeon. This gentleman informed me that the plant was fatal to stock, narcotizing them when eaten, the effects in some instances coming on slowly, and remaining sometimes as long as two years. As dangerous properties are rare in leguminous plants, I thought that these observations were worthy of record.

The felspathic rock is here easily decomposed, so that, instead of forming the crests of the mountains at the Sangre de Cristo Pass, it occupies the valleys of the western slope of the range. The elevated parts of the pass are composed of sedimentary rocks, while the mountain-peaks of the region are of rhyolite and other intrusive material.

The granitic beds are stratified, dipping northeast. They are either heavily-bedded feldspathic porphyry, or more finely-bedded hornblendic gneiss, with much hornblende in fine grains.

The following figure represents some of these beds, which have an intermediate mineral character, and are located near the eastern border of the formation. The *débris* of this formation forms hills, which furnish placer-gold diggings, which are now worked with some success.

The western part of the granite belt is excavated into a basin, which forms a branch of the great basin of the Rio Grande, or San Luis Valley, and which was once filled with a deposit of Tertiary age. To within eight miles of Fort Garland, I found north of the road a series of benches composed of the sediments of this lake, viz: beds of clayey sandstone alternating with heavier beds of moderately fine to very coarse conglomerate. The conglomerate contains rounded pebbles of chlorite, quartz, red sandstone, basalt, &c., and its strata lie horizontally against the oblique beds of the granite toward the pass. Dr. Hayden has described this formation from more northern parts of the San Luis valley, and I discovered the corresponding members of it on my return trip on the western side of the valley, occupying the lateral valleys of the San Juan range. In the latter locality, it presents the same features as in the Sangre de Cristo Valley, being composed of alternating beds of clayey sandstone and coarse conglomerate, and reaching a thickness of 800 and 1,000 feet. On the upper waters of the San Antonio Creek it forms bad-land tracts, with the characteristic scenery. There can be, then, no reasonable doubt that, as proposed by Dr. Hayden, the upper as well as the lower part of the valley of the Rio Grande was once entirely filled with the deposit of a Tertiary lake, which I have elsewhere identified with the horizon of the Loup Fork epoch.

Eight miles east of Fort Garland several masses of basalt form rough hills, with a southwest and northeast trend, and the road rises to a higher level, while the creek cuts its way through a small cañon. The characteristic features of the Rio Grande Valley now come into view in flat-topped mesas, with steep sides, capped with a bed of basalt. Their sides are covered with masses broken from the face of the stratum of basalt, allowing of no vegetation or a few yuccas and sage-brush. The floor of the valley from this point to the Rio Grande, a distance of twenty miles, and for a greater distance to the west side of it is level and barren, being covered over with sage (*Artemisia*) and brush-like *Compositæ*. Near Fort Garland its soil is everywhere mingled with gravel of the decomposed pink porphyry. The flat-topped black basaltic mesas are distributed on both sides of the Rio Grande, and form prominent objects for thirty miles below Fort Garland. The Rio Trinchera, passing the fort, enters the Rio Grande on a level plain, but not many miles below its mouth the river enters a cañon cut into the bed of basalt, which constitutes the floor of the plain, and only emerges at intervals during a course of one hundred miles to the south. Two round basaltic masses are distinguished among the mesas, the San Antoino and the Ute Mountains.

FIG. 1.—Strata of feldthspathic porphyry and gneiss on Sangre de Cristo Creek, near the pass.

The prevalence of the basaltic rock gives the valley of the Rio Grande a forbidding character both to the agriculturist and the geologist. The concealment in a deep cañon of the great river, which, under other circumstances, would have been to it what the Nile is to Egypt, has relegated a great part of its surface to comparative sterility. This is relieved by the many creeks of pure water which issue from the mountains and carry fertility in their courses across the east side of the valley. Such are the Costilla, the Colorado, the San Cristoval, and the Honda.

Near the Colorado Creek, at the foot of the mountain, I observed an interesting example of the decomposition of basalt. This rock is usually in this region porphyritic, including small masses of a light-colored feldspar, which is often weathered out on exposure, leaving a vesicular structure of the surface. At the cañon, where the Colorado Creek issues from the mountain, it traverses a vertical mass of protruded basalt of 800 feet in elevation. In the least altered portions, near the summit, the base of the mineral is a bluish lead-color, contrasting strongly with the small masses of white feldspar. At a lower elevation, the base is rusty-brown or yellow, the white bodies far less distinct. In the lowest part of the bluffs, say for 200 feet, the rock has a homogeneous appearance, and is pure white, like kaolin. From these white rocks, near the base, issues a chalybeate spring, sour with excess of sulphuric acid. At its point of exit is a deposit of alum.

At the mouth of the Rito Honda, the Rito Grande flows through a cañon of 800 feet in depth. No Tertiary beds are visible until we reach the valley of Taos. This fine tract of land, drained by the Taos Creek and its tributaries, occupies an amphitheater in the Sangre de Cristo Mountains, which sends a strong spur off to the Rio Grande on the south side of the valley. Numerous villages constitute the general settlement of Taos, not the least interesting of which is the Indian town, or pueblo, of agglomerated houses of that name. The mesas bounding this valley on the north are composed of a coarse gravel of worn pebbles and cobble-stones derived from the mountains. They are cemented together slightly by a calcareous substance to a depth of 2 to 4 feet, and the deposit has more the appearance of being a late drift than a part of the Pliocene lake-deposit previously described. The transported material shows plainly that the western flanks of the mountains are chiefly composed of gneiss, quartzose granite, and quartz-

ite; but little of the Rocky Mountain felsdpar-porphyry appearing. This appearance was confirmed by an examination of the spur bounding the valley on the south.

Mr. Sanchez showed me a tooth of the *Mastodon ohioticus*, which was found in the clay of the valley along the Rancho Creek.

The axis of the Picuris Mountains, the western spur of the main range already mentioned, is gneiss rock, portions of which are filled with garnets and crystals of hornblende and tourmaline, and which incloses at some localities masses resembling a hard soapstone. The sedimentary rocks rest upon its northern face at various dips, often 35° and 45°. I made a section by following the valley of the Rancho Creek, which cuts the strata at right angles for about eight miles. On entering the ravine, the first formation is a siliceous limestone, dipping northwest 35°; beyond, *i. e.*, below this, appears a bright-red conglomerate, which greatly resembles the Triassic beds of other localities. It changes in long weathering to a dirty greenish color on exposed points. It is continued into a sandstone, which has a dip of 45° northeast, and a thickness of more than a thousand feet. They contain innumerable vegetable remains, mostly leaves of a reed-like form. This deposit is underlaid by the limestone of the Carboniferous period, which is at the top thin-bedded and alternating with dark-colored shales. I found here great numbers of characteristic fossils, weathered out and beautifully preserved; including Echinoderms, Crinoids, small species of *Orthoceras*, *Goniatites*, *Spirifers*, and other *Brachiopoda*, with Gastropods resembling *Trochus*, *Turritella*, and *Nerita*. About ten miles southeast of the point where the Rancho Creek issues from the mountains, in a rugged ravine, is an outcrop of coal, which has been exposed by Mr. Sanchez. I visited the locality, and found a bed of coal of an inferior quality of 15 to 18 inches in thickness, dipping north 30°. The rather shaly strata above it are filled with Carboniferous fossils. Another bed of coal near the mouth of the cañon of the Rancho is of still less value; thickness, 15 inches; dip, 45° north. The rocks of the Trias and Carboniferous form an open anticlinal ridge before finally rising to the axis of the Picuris Mountains.

The ravines of the south side of the Picuris Mountains are filled with the arenaceous beds of the Santa Fé marls, as already described by Dr. Hayden. The erosive forces have cut deep valleys and gorges from their mass, leaving tremendous castellated and bastioned escarpments of a thousand feet elevation. Interesting views of these beds may be had by following the valley of the Embuda Creek, and the cañadas which extend from it to the southward and eastward. After careful examination, I could only find a single fossil, namely, a penultimate phalange of a lateral digit of probably a three-toed horse.

Crossing the Rio Grande by a ford not far from the mouth of the Embuda Creek, I climbed the rugged face of the lava mass that forms the sides of the cañon of the river, and which underlies the region on its eastern side, and found myself at the base of the "Pliocene" sands, which there form bad-land hills of much elevation. Some of them are worn into castellated forms of much beauty; one in particular reminding me of the Eocene Church Buttes of Wyoming. From their summits an extensive view was had of the triangular area inclosed on two sides by the Rio Grande and the Rio Chama, with the two drainage-areas of the Ojo Caliente and El Rito Creeks. On traversing this region, it was found to be entirely composed of the "Pliocene" sands, and to be very arid, with cedars scattered irregularly over the surface. The springs of Ojo Caliente number three, the most important issuing from a vertical ledge of gneiss, which is there traversed by a wide quartz-vein. The temperature of the warm springs is from 116° to 120°; they contain abundance of a confervoid alga. In the creek below I saw a cyprinoid fish (*Gila pandora*, Cope) taken with the hook. Near to this point I first observed the blue partridge, (*Callipepla squamata*, Vig.,) which is readily distinguished as it runs by the white under side of its erect top-knot.

In descending the Rio Chama, the arenaceous bluffs are continually in view on the north side, and occasionally display layers of basalt alternating with the sandstones. In this situation, the basalt is at times concretionary. The bed which bounds the Rio Grande on the west terminates at the junction of the Chama in a high point. On the southwest side of the Chama, a similar stratum gives the mesa form to the hills nearly to the mouth. South of these the Jemez Mountains rise in impressive proportions, and, extending southward, bound the Rio Grande Valley on the west.

The wide valley between the Jemez and the Sangre de Cristo ranges is almost entirely filled with the Santa Fé marls. Their sandy character is not favorable to agriculture, being scarcely preferable to the basalt, so that cultivation is confined to the narrow valleys of the tributaries of the Rio Grande. The intervening country is either absolutely naked or covered with cedars. Occasionally, as near San Ildefonso and near San Felipe, a fragment of the lava remains, protecting the underlying Pliocene beds, forming a flat-topped butte, generally termed a Huerfano. The beds of the Santa Fé marls are alternately softer and harder sandstones and conglomerates, varying from white to greenish-gray and to light rufous. They dip generally 10° to 15° toward the east, and away from the basaltic mass of the Jemez range. They contain the remains of extinct *Vertebrata*, mostly *Mammalia*, which have enabled

me to correlate them with the Loup Fork Tertiary of Colorado and Dakota.* The species discovered by our party number twenty-nine, of which twenty-four are *Mammalia*, three birds, and two reptiles. An enumeration of them is given in the chapter which follows the present one.

Twenty-five miles west of the Rio Grande, at San Ildefonso, the eastern masses of the Jemez Mountains rise. The greater part of this interval is occupied by a plateau which is traversed by more or less parallel ravines, which issue in the trough of the Rio Grande. The mesas which separate the ravines terminate abruptly like the wharves of a city-front. Their material consists of sandstone, conglomerate, and arenaceous marl, of whitish, gray, and drab colors, having a gentle dip to the northwest. Many of their upper beds contain numerous pieces of pumice, which readily disintegrate, and the resulting siliceous dust under the influence of wind excavates the surrounding sandstone into caverns and pigeon-holes of many sizes and shapes. Nearer the mountains the northwest dip of the beds is distinct, and they accordingly present escarpments to the southeast and gentle pine-covered slopes to the northwest. The ravines have a northeast and southwest direction, and extend to the base of the mountain. The escarpments are composed of orange-colored and reddish rock of uniform constitution, which breaks into prism-like masses as it falls, forming taluses below. It is entirely distinct in character from that of the bluffs nearer the river, which form part of the Santa Fé Tertiary marls, as proven by the occurrence of the bones of *Mastodon* and *Aceratherium Jemezanum*, Cope, near Santa Clara.

The orange beds are doubtless older, and were afterward seen on the Chama River; but I was unable to determine their age, or their precise relation to the overlying sands and marls. They are covered near the mountains by a mass of basalt, which forms the floor of a higher mesa, from which rise the basaltic cones of the Jemez Mountains. Some of its peaks were doubtless sources of discharge of lava at a former period. I did not observe that the orange beds were tilted, or rested other than nearly horizontally against them.

In the ascent of the Rio Chama, we pass over the Santa Fé marls exclusively until reaching the town of Abiquiu. Here are bluffs of 700 feet in elevation, of a soft sandstone, having the same character and dip (10° to 15° northwest) as those above described as at the eastern base of the Jemez Mountains. In a bay on the western side of one of these bluffs is a patch of picturesque bad-lands of the Santa Fé marls. Five miles above Abiquiu, the brilliantly-colored yellow and red beds which form such an important feature in the geology of Western New Mexico, appear in high bluffs on the north side of the river. They are several hundred feet in thickness, but near the Rio Chama descend so as to permit of a view of their relations to the superincumbent beds. The brightly-colored beds are cut by a ravine to a depth of about 150 feet. The upper portion is yellow, and they dip 25° southwest. They are overlaid by a shale of 15 feet in thickness, whose laminæ are frequently contorted. The lower part of the bed is finely laminated, and the upper portion consolidated into a very hard rock. Above it is a bed of 20 feet of a very coarse conglomerate, whose cement is arenaceous. (See Fig. 2.)

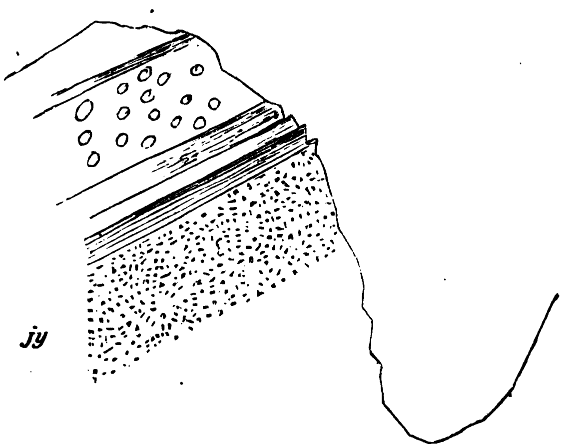


FIG. 2.—Outcrop of "Jurassic" strata near Abiquiu.

These details are entered into for the purpose of exhibiting the unconformability between the late Tertiary beds of the Rio Grande Valley and the formations constituting its western shores. The beds just described are believed to correspond with those called Jurassic in the section taken at Colorado Springs, and quoted in my introductory remarks. Red beds, supposed to correspond with the Trias of the same section, were observed by me to form the northern boundary of the basin a few miles north of the town of El Rito, east of the Rio Chama. These beds crop out in high bluffs, and doubtless formed the precipitous western shore of the fresh lake which during the

*See Report on the Vertebrate Fossils of New Mexico, Annual Report Chief of Engineers, 1874, p. 603.

Loup Fork epoch filled the valley of the Rio Grande from its upper waters to an unknown distance toward Mexico.

These red and variegated beds cover the stratigraphical axis of the Sièrra Madre at this point, although not the water-shed between the waters of the Rio Grande and Rio Colorado. The geology west of this point will be considered in the chapter devoted to the Sierra Madre and the area west of it.

CHAPTER III.

THE VERTEBRATE PALEONTOLOGY OF THE SANTA FÉ MARLS.

The earliest information which we possess respecting the existence of vertebrate remains in the lacustrine deposits of the Rio Grande Valley is due to the interest displayed by Hon. Wm. F. M. Arny, then governor of New Mexico. He obtained from the region northwest of Santa Fé the fragments of a lower jaw of a *Mastodon productus*, Cope, and sent them to the Smithsonian Institution. This specimen formed the subject of a description by Dr. Leidy, who referred the species to his *Mastodon obscurus*.* The next observations of vertebrate fossils were made by the members of your expedition of 1873. Francis Klett obtained a number of specimens from near San Ildefonso. Following the directions of this gentleman, I made the examination during the season of 1874 which resulted in the discovery of twenty-nine species of *Vertebrata*, of which all but four are determinable. Some of these have been already described in my report to you, published in the Annual Report of the Chief of Engineers for 1874, page 603.

The following list embraces the names of all the species and descriptions of such as have been heretofore unknown:

CARNIVORA.

Canis ursinus, Cope, Proceedings of the Philadelphia Academy, 1875, p. —.

This large dog is the largest carnivorous animal observed in the fauna, equaling in dimensions the *Ursus americanus*. It approaches the *Amphicyous* in the great development of its tubercular molar teeth, and is allied to the *A. Haydenii*, Leidy, from the Loup Fork beds of Nebraska.

It is distinguished for the large size of the canine teeth and the small size of its premolar teeth. The premolars are separated from each other and from the canine by short subequal diastemata; but the fourth premolar and the true molars form an uninterrupted series. The first tubercular molar is larger than the last premolar, and the second tubercular is but little smaller than the same tooth, and has its single flat root so grooved as to foreshadow the two-rooted condition seen in the *A. Haydenii*. The mandibular ramus is deepened posteriorly, and is remarkable in the great anterior prolongation of the masseteric fossa, which reaches as far as below the middle of the sectorial molar tooth. The dimensions are as follows: Length of molar series from alveolus of canine, $0^{m}.121$; length from same to sectorial molar, $0^{m}.061$; length of sectorial, $0^{m}.031$; width of crown of sectorial, $0^{m}.012$; depth of ramus at posterior border of sectorial, $0^{m}.055$; depth of ramus at anterior border of sectorial, $0^{m}.049$; depth of ramus at first or simple premolar, $^{m}.038$; long diameter of canine tooth, $0^{m}.023$. From *A. haydenii* the species differs in the position of the tubercular molars, being on the continuous alveolar border, as in typical dogs, in the one-rooted second tubercular tooth, and in the anterior extension of the masseteric fossa.

Canis sævus, Leidy, Extinct Mamm. Dakota and Nebraska, p. 28.

A mandibular ramii of this species, which is, as Leidy observes, much like the *Canis lupus*.

Canis vafer, Leidy, loc. cit., p. 29.

Mustela nambiana, Cope.—*Martes nambianus*, Cope, Report on Vertebrate Fossils of New Mexico, Annual Report Chief of Engineers, 1874, p. 603.

ARTIODACTYLA.

Dicrocerus gemmifer, Cope. *Merycodus gemmifer*, Cope, Annual Report of United States Geologcal Survey Territories, 1873, p. 531.

The genus *Dicrocerus* was proposed by Edouard Lartet in 1839 for ruminants which combine the character of the deer and the antelopes. In 1851 the genus was further defined by him, and it was observed that in some of the specimens the horns are continuous with the frontal bones, as in the antelopes, &c., while in others there is a union

* Report of the Geological Survey of the Territories, vol. i, (4to,) p. 235.

of the beam with a basal protuberance of the frontal bone by a burr. These observations have been made on the American species by myself, and published in the report on the Vertebrate Fossils obtained in New Mexico, (see Annual Report Chief of Engineers, 1874, p. 604.) The specimens obtained by the expedition prove that three, perhaps four, species of this genus occur in the Santa Fé marls, one of which had been previously found by myself in the Loup Fork beds of Colorado and another in the corresponding formations in Nebraska by Dr. Hayden. To the latter the name of *Merycodis necatus* was applied by Dr. Leidy in 1854 and *Cervus Warrenii* in 1858. The former was represented by mandibles with dentition; the latter by horns. The discovery of crania with horns and teeth enables me to unite these supposed species. A third species, discovered by Dr. Hayden in Nebraska, was named by Dr. Leidy *Cosoryx furcatus* in 1869. In commenting on this species, Professor Gervais remarks (*Journal de Zoologie*) that the genus *Cosoryx* is not distinct from *Dicrocerus*, a statement confirmed by the comparison with the figures of the *D. dichotomus*, Gerv., from the French Miocene. I described an allied epecies, *D. ramosus*, from the Santa Fé marls. Finally, a species considerably larger than any of the preceding was described by me under the name of *Cosoryx teres*.

The *D. gemmifer* is distinguished from the other species of the Santa Fé marls by its materially smaller size.

Dicrocerus necatus, Leidy.—*Merycodon necatus*, Leidy, Proceedings Academy Philadelphia, 1854, 90; Extinct Mammalia Dakota and Nebraska, 162.—*Cervus Warrenii*, Leidy, Proceedings Philadelphia Academy, 1858, 23; Extinct Mammalia Dakota and Nebraska, 172.

Abundant in the Santa Fé marls.

Dicrocerus ramosus, Cope.—*Cosoryx ramosus*, Cope, Report on Vertebrate Fossils, New Mexico, Annual Report Chief of Engineers, 1874, p. 604.

Abundant.

Dicroceerus teres, Cope—*Cosoryx teres*, Cope, Report, l. c., 605.

Pliauchenia Humphresiana, Cope, gen. et sp. nov.

Char. gen.—Represented in the collection of the expedition by a left mandibular ramus, which includes alveoli of all the teeth, and greater or less portions of all the molars, except the last, and the first premolar. In the specimen, the dental formula is I. ? 3; C. 1; Pm. 3; M. 4; or one premolar less than in *Procamelus*, and two more than in *Auchenia*. On this ground, the present animal is regarded as representing a new genus of *Camelidæ* intermediate between the genera named. A portion of the left maxillary bone of a larger species is thought to belong to the same genus, although it presents the number of premolars found in *Procamelus*, viz, four. The first and second are, however, very close together, so as to leave about the same relative interval between the first and third, as is seen in the *P. Humphresiana*, should the second premolar be omitted. The latter tooth is wanting from the lower jaw of the *P. Humphresiana*. The difference in dental formula between the superior and inferior dental series admitted provisionally in *Pliauchenia* finds justification in the formula of the llamas (*Auchenia*) where the premolars are $\frac{3}{3}$.

Char. specif.—The animal now described is of about the size of the *Procamelus occidentalis*, or somewhat larger than any of the existing llamas. The mandible is stout and deep, contracting rapidly forward. The canine and first premolar are especially stout, and separated by a very short diastema; that separating the first and third premolars is also short, being less than that which separates the first and second in *Procamelus occidentalis*. Could it be supposed that the second premolar is abnormally absent from the *P. Humphresiana*, the diastema would be reduced to a very small compass. Without this supposition, the diastemata, both before and behind the first premolar, are shorter than in any of the *Procameli*, as *P. robustus*, *P. angustidens*, *P. heterodontus*, and *P. gracilis*. The mental foramen issues below the anterior border of the first or caniniform premolar, and the anterior border of the latter marks the posterior margin of the symphyseal suture. The third premolar is nearly as long as, but narrower than, the fourth, and the true molars increase rapidly in size posteriorly.

Measurements.

	M.
Length of dental series from front of canine to front of last molar	.125
Length from canine to first premolar	.010
Long diameter of first premolar	.010
Diastema to third premolar	.023
Length of third premolar	.011
Length of first true molar	.019
Width of crown of first true molar	.011
Length of crown of second true molar	.025

This species is dedicated to Brigadier-General A. A. Humphreys, Chief of Engineers, U. S. Army, in recognition of the enlightened interest in all departments of scientific investigation exhibited in his long and able administration.

Pliauchenia vulcanorum, Cope, sp. nov.

Represented by the left maxillary bone of a camel of about the size of the existing dromedary, and considerably larger than the species last described. The dental formula is molars 4–3. The first premolar is only removed from the second by a diastema equal to the long diameter of the latter. The latter has no inner cingulum, while in the third it is so strong as to constitute an internal crescent. The third is much larger, and exhibits the usual single external and single internal crescents. The first molar is stout, long-rooted, and furnished with a strong ridge on the outer side, bounding the posterior crescent-bearing column in front. There is a weak ridge on the middle of the anterior column, and only a rudiment on the last premolar. There are no cingula on either the inner or outer bases of the crown. The enamel is nearly smooth. A palato-maxillary foramen issues opposite the anterior border of the base of the third premolar.

Measurements.

	M.
Length from posterior border of first premolar to posterior border of first molar.	.090
Length of first true molar	.030
Width of base of crown of first true molar	.024
Length of fourth premolar	.019
Width of base of crown of fourth premolar	.018
Width of palate at first true molar	.040

The typical specimen was found near Pajuaque, a village of the Pueblo Indians. Various bones of camels of the size of the *P. vulcanorum* were also found, some of which doubtless belong to it.

Procamelus gracilis, Leidy, Extinct Mammalia. Dakota and Nebraska, p. 155.

Specimens which present the measurements of this little known species are provisionally referred to it.

Procamelus occidentalis, Leidy, loc. cit., p. —.

The cranium of this species is not unlike that of the llama, but is, as might be anticipated from the dental characters, more elongate. I am also able to demonstrate on this species, as I already have on the *P. heterodontus*,* Cope, the presence of the second incisor teeth. As the specimen described is not quite adult, the first pair do not appear, but the alveolar border is excavated at their normal position. An extensive fossa is situated above the posterior premolar series of teeth, and greatly contracts the middle of the facial part of the skull. The anterior part of the maxillary bone is concave, and overhung by the superjacent regions, causing a second fossa, which contracts the palatal face. These fossæ are represented by rudiments in the *Auchenia lama*. In addition, the cavities known as "*larmiers*" in the *Cervidæ* are well developed in this species, being many times as large as in the llama, and quite equal to those possessed by some deer. The supraorbital foramen communicates with the superciliary border by an open fissure; the lachrymal bone is large. The cranium resembles that of the llama in its moderate sagittal crest, elongate paramastoid process and otic bula, and the downward production of the pterygoid bones. The incisive foramina are narrow and distinct.

The ulna and radius are thoroughly co-ossified. The carpus displays the characters of the *Camelidæ* in the absence of trapezium and distinctness of trapezoides, and the subequality of the magnum and unciform facets of the lunæ. There are but two metacarpals, which, in the specimen described, are only co-ossified in their proximal half. As the last molar tooth is only two-thirds protruded, the present animal is not fully adult; in an older specimen, the cannon-bone is doubtless completed.

In general proportions, the *Procamelus occidentalis* much resembled the llama.

Merychyus medius, Leidy, Extinct Mammalia of Dakota and Nebraska, p. 119.

One side of the facial region with superior dentition, with other remains, represents this Oreodont.

PERISSODACTYLA.

Hippotherium calamarium, Cope, sp. nov.

This three-toed horse is indicated by the oval and palatine parts of the skull with the superior dental series of both sides, together with one mandibular ramus, with all its teeth, of an individual from near San Ildefonso, and also probably by molar teeth of two individuals from the Loup Fork beds of Colorado. The species is allied to the

* Annual Report of the United States Geological Survey of the Territories, 1873, p. 530.

PLATE II.

E. C. Beaux.

T. Sinclair & Son, lith. Phila.

PROCAMELUS OCCIDENTALIS, CRANIUM, SIDE VIEW. ½

H. paniense, Cope, and differs from the *H. occidentale*, *H. speciosum*, and *H. gratum* of Leidy in the relative form and size of the internal anterior dentinal column. In the two species first named, this column is subcylindric and equal to, or smaller than, the posterior internal columnar fold; in the three species last named, the anterior column is flattened or oval in section, and often larger than the posterior columnar fold, and submedian in position.

In the typical or New Mexican specimen, the anterior column is large, and its center is anterior to the middle transverse line of the crown. In the present state of attrition, which has left two-thirds of the crowns of the median molars, this column presents an angular projection toward the inner anterior crescent, betraying an approach to the union seen in *Protohippus*, which is in the fifth molar of the right side of the present horse actually accomplished through the medium of a narrow isthmus. The dentinal band connecting the inner crescents throws out two, rarely one, folds toward this column. The borders of the lakes are much plicate; the posterior border of the anterior lake having from four to six inflections. The posterior border of the posterior lake exhibits one deep inflection, which is generally bifurcate.

The first premolar is quite small, and is two-rooted; the second is a wide tooth, different in form from the elongate corresponding tooth of the *H. occidentale*; its anterior lobe being but little prominent. The palate is wide and well arched. The mandibular teeth are elongate but not narrow; and the interior lobes are well developed, especially the median ones. No basal cingula on teeth of either jaw. The last molar is smaller than the three preceding it, and the anterior lobe of the first is quite narrow.

The molars of one of the specimens from Colorado are closely similar in all respects except that the anterior lobe of the second premolar is a little more produced. I also refer here the tooth described as "M. 2" under *H. paniense* in Report of the United States Geological Survey of the Territories, 1873, p. 522–523. As compared with the molars of that species, those of *H. calamarium* differ in the much greater complexity of the enamel folds; those of the *H. paniense* being the simplest in the genus, even more so than in *H. affine*. The anterior inner column of *H. paniense* lacks the characteristic inner angle seen in the present horse.

Measurements.

	M.
Length of seven superior molars	.134
Length of three true molars	.062
Length of second premolar	.026
Width of crown of second premolar	.020
Greatest length of second premolar	.022
Greatest width of second premolar	.024
Greatest length of penultimate molars	.022
Greatest width of penultimate molars	.022
Width of palate (chord) between middles of third premolars	.042
Length of crown of antepenultimate lower molar	.021
Width of crown of antepenultimate lower molar	.012

The typical specimen belongs to an adult animal, and was taken from the matrix by myself, without admixture of others.

Hippotherium speciosum, Leidy, Extinct Mammalia of Dakota and Nebraska, p. 282.

Series of superior molars nearly identical in character with those originally described as typical of this species by Dr. Leidy, and figured on Plate XVIII, Figs. 16, 18, 19, of the work above quoted, and agreeing with specimens from Colorado. Some of the specimens described by Dr. Leidy as of doubtful reference under the head of this species obviously do not belong to it.

Protohippus, spec. indet.

A single much-worn molar, of the size of that of *P. sejunctus*, apparently represents this genus.

The specimens obtained indicate another species of horse, but they are not sufficiently characteristic for determination.

Aphelops meridianus, Leidy.—*Rhinoceros meridianus*, Leidy, Extinct Mammalia of Dakota and Nebraska, p. 229.

Remains of rhinoceros are not rare in the deposits of the ancient lake of the Rio Grande valley, and among the most complete fossils obtained is the greater part of the cranium of a species allied to the *Aphelops megalodus* of the corresponding beds of Colorado. The specimen includes the dentition of both jaws, which exhibits the following formula: I. $\frac{2}{2}$; C. 0; Pm. $\frac{3}{3}$; M. $\frac{3}{3}$. The absence of the first premolar distinguishes the form from the Miocene *Aceratherium* as well as from the existing genus *Rhinoceros*; while the presence of inferior incisors separate it at once from the living *Rhinaster*. I have named this genus *Aphelops*; like *Aceratherium*, it is hornless. To it are referred,

besides the species mentioned, the *Rhinoceros crassus*, Leidy, and the *A. Jemezanus*, first described below. These are, however, only referred to it provisionally, as the number of the premolar teeth is not yet known in either. The known species have only been found in the beds of the Loup Fork epoch.

The *A. meridianus* was established by a superior molar tooth from Texas.' The corresponding molar in the New Mexican species does not differ from it. The general characteristics of this almost unknown species may then be learned from our specimens. In general features it much resembles the *A. megalodus*, but there are numerous differences. There is a considerable protuberance of the anterior border of the posterior transverse crest, nearer the outer border of the crown than the protuberanee of the posterior border of the anterior transverse crest. These give the transverse valley a sigmoid form, which is not seen in *A. megalodus*. There is no posterior protuberance of the anterior transverse crest of the last superior molar. There is a strong anterior basal cingulum on the true molars, and a very strong elevated cingulum connecting the inner ends of the transverse crests. No external cingula.

The mandible differs from that of *A. megalodus* in the contracted form of the symphysis, and the small size of the outer tusk-like incisors, which are scarcely half as large as those of the former; but it is possible that this character is sexual. As compared with five mandibles of *A. megalodus*, the last molar originates closer to the base of the coronoid process; in the latter there is a considerable interval in front of the ascending process. The form of the dentary bone is that of *A. megalodus*, and not thick and massive as in *A. crassus*.

Aphelops Jemezanus, Cope, sp. nov.

That a second species of rhinoceros even larger than the other species of *Aphelops* formerly existed in the region of New Mexico is demonstrated by a right mandibular ramus obtained by Dr. H. C. Yarrow from near the town of Santa Clara, on the west side of the Rio Grande. The specimen in its present condition includes the condyle, angle, and ramus as far as the last premolar, and supports the three true molars. The latter are worn, indicating the full age of the animal. They still retain the enamel surface of the sinus between the posterior and median transverse crests, and the lower end of the sharp inner margin of the anterior transverse crest.

While the ramus exhibits the compressed form seen in *A. megalodus* and *A. meridianus*, it differs from these and the *A. crassus* in many striking respects. Thus the inferior margin near the angle does not exhibit the protuberance and following contraction of the inner side seen in the first two species. In another feature it differs from all the other species, *i. e.*, in the form of the ascending ramus. This rises very gradually from the basis of the last molar, leaving a subhorizontal edentulous space behind the latter as long as the second true molar; its anterior face, instead of being flat and bounded by strong lateral angular ridges, as is the case in *A. crassus* and the two other species, is rather narrowly convex. Instead of the usual ridge of the outer side, the anterior border of the area of insertion of the masseter muscle is marked by a prominent curved protuberant margin, which is wanting in the three other species; the surface in them being plane. Behind the condyle is seen the tuberosity characteristic of the *Rhinoceridæ*. The internal pterygoid fossa is well marked. Rugosities for insertion of the lower border of the masseter muscle are strong. The relations of the dentition of this species are also peculiar. The last molar is nearly half as large again as that of specimens of *A. megalodus* and *A. meridianus* of similar dimensions of ramus, and the teeth diminish in length anteriorly more rapidly than in width. Thus while the first true molar is as long as in the two species named, the width is between one-half and one-third greater. There are no external nor internal basal cingula.

Measurements.

	M.
Length of ramus from fourth premolar (behind) to middle of masseteric fossa	.240
Length of series of true molars	.148
Length of first true molar	.044
Width of first true molar	.033
Length of third true molar	.058
Width of third true molar	.035
Diameter of ramus at first molar	.080
Depth of ramus at third molar	.092

PROBOSCIDEA.

Mastodon productus, Cope, Proceedings of the Philadelphia Academy, 1874, p. 221.

Fragments of the skeletons of this species are quite abundant in the Santa Fé marls, and, as it is the most striking species of the ancient fauna, was the first to become known. The dentition of both jaws was obtained. It belongs to the typical mastodons, and is nearly related to the *M. angustidens* and *M. longirostris* of Southern Europe,

and, like them, has a band of enamel extending along the superior tusks, and a much produced symphysis of the mandible, from which two smaller tusks project.

The posterior-inferior molar supports five transverse series of tubercles, of which the posterior is less developed than the others. Each series is composed of two cusps of a conic form, which are separated deeply from each other, and are not united at the base so as to become confluent on attrition. The cones of the outer side support one or two accessory tubercles on a line with their inner or median face, so that the transverse section of a worn tooth with the two accessory cusps is that of a trefoil with the lobes inward.

The penultimate molar in the same jaw supports three transverse series. The symphysis is elongate, depressed, and subspatulate; its proximal half is excavated; the distal half flattened. Two tusks project from the extremity; they are short, obtuse, and flattened on the inner side. Total length of a specimen which is entire from the end of the symphyseal tusks to just behind the last molar, 29 inches; length to first molar, (penultimate,) 19 inches; length of first molar, 4.25 inches; of last molar, 6.5 inches; width of same, 3 inches; width across the rami at end of last molar, 18 inches; width between anterior borders of first molar, 2.5 inches; width of symphyseal spout, least, 4.5 inches; at base, tusks, 4.75 inches; length of free portion of symphyseal tusks, 4 inches; diameter of symphyseal tusks, 1.75 inches.

The North American mastodons are referable to two groups, characterized by the structure of their molar teeth. In the first, the cross-crests are divided by a fissure only, the other by the transverse series of two or more deeply separated tubercles. To the first belong *M. ohioticus*, Cuv., and *M. proavus*, Cope; to the second, *M. Chapmanii*, Hays, (from which *M. obscurus* could not be at present distinguished;) *M. Shepardii*, Leidy; *M. andium*, D'Orb., (the last two referred by Leidy to *M. obscurus*;) *M. mirificus*, Leidy, (closely allied to *M. Humboldtii*;) and *M. productus*, Cope.

No question as to the distinctness of the *M. productus* could arise, although our knowledge of the *M. Chapmanii*, to which it has been referred, is very slight. As described by Drs. Hays and Leidy, the lateral tubercles of the molars in that species are closely appressed or not separated; being sometimes continuous across the crown of the tooth. This description applies to one of the specimens (a cast) selected by Dr. Leidy as his type, and to a second specimen referred by him to the *M. andium*. The second type-specimen of Dr. Leidy, a fragment of a posterior molar, is undistinguishable from corresponding parts of *M. andium*. The *M. Shepardii*, as described by Leidy, is evidently quite distinct from both the preceding and from the *M. productus*, in the absence of accessory tubercles of the lateral principal cusps of the molars.

The specimens are chiefly from the east side of the Rio Grande; but a few were obtained near Santa Clara on the western side.

RODENTIA.

Panolax sanctæfidei, Cope, Report on Vertebrate Fossils of New Mexico, Annual Report Chief of Engineers, 1874, p. 605.

Eumys loxodon, Cope, loc. cit., p. 605.

This rat is represented by a mandibular ramus containing all of the teeth. These are identical in essential structure with those of the *Eumys elegans*, and the species is therefore provisionally referred to that genus. I originally described it as a *Hesperomys*, a genus to which it is also closely related so far as the preserved portions indicate.

Steneofiber pansus, Cope, Proceedings of the Philadelphia Academy, 1874, 22.

The molar teeth exhibit a regular gradation in width from the large anterior to the small posterior. In the mandibular series the second and third are broader than long; the first and fourth longer than broad, and with an angle on the outer anterior side of the crown. There is an inflection or groove of the enamel on both inner and outer sides of the crown, and one enamel-area before and one behind them on all excepting the last molar, where there are two in front. First nearly twice as large as last molar. Lower incisor with smooth enamel, and angulate on the extero-anterior border. Ramus stout. Length of molar series, $0^m.016$; length of first molar, $0^m.005$; width of first molar, $0^m.004$; width of last molar, $0^m.0035$; transverse diameter of incisor, $0^m.004$; depth of ramus, $2^m.012$.

The regular diminution of the size of the teeth from front to rear is characteristic of this species according to Dr. Leidy; their reduction in size in the *S. Nebrascensis* is more abrupt. The latter species is said to be of Miocene age.

AVES.

Vultur umbrosus, Cope.—*Cathartes umbrosus*, Cope, Report on Vertebrate Fossils of New Mexico, Annual Report Chief of Engineers, 1874, p. 606.

The elongate beak and weak toes of this genus resemble those of the vulturine types, and the absence of any indication of nasal septum at the fractured base of the

beak, gave ground for the reference of this species to the family of American vultures. On excavating the matrix from the right nostril, I find that the nasal septum is present, and extends throughout the length of the nares, indicating at once its reference to the *Falconidæ*. The elongate gonys, inferior production of the nares, and stout tarso-metatarsus refer the form to the neighborhood of the Old World vultures, now properly regarded, after Huxley, as a division of the *Falconidæ*. This determination, although rather unexpected, is consistent with the presence of the Old World genera of deer, rhinoceros, &c., in the same fauna. It gives the first intimation of the presence of true vultures on the American continent.

? ——— ———. A second species of rapacious bird is represented by bones of the fore limb, &c. Its size is about half that of the preceding species.

? ——— ———. The principal phalange of a third species of bird of the group of the ——— was also obtained.

TESTUDINATA.

Lestudo undata, sp. nov.

Two species of tortoises occur in association with the fauna described in the preceding pages, but their remains are mostly found in a fragmentary condition. Hence, although I procured nearly all portions of the skeleton, in no case do they belong to a single individual. None of the fragments belong to species of any other genus, unless it be *Stylemys*. I possess the caudal vertebræ and a metapodial bone of one of the species recognized, and the latter indicates in the clearest manner that it is a *Testudo*. It is wider than long, and totally different from the elongate metapodials of *Stylemys*. As already pointed out,* these have the form characteristic of the *Emydidæ*, to which family the genus is to be probably referred. The caudal vertebræ are few and short, and have the procoelian character. They are without chevron-bones.

The greater part of a plastron was obtained, which I describe here, as it cannot be definitely referred to its proper species. It is quite thin medially, as in various Testudas, and is not much thickened within the fore border, as is the case in many species of that genus and of *Hadrianus*. The bridge is thin and the axillary borders are thickened, but not prominent inward. The end of a mesosternal bone is rather produced, and has not the lateral expansion seen in some Testudines and *Stylemys Nebrascensis* and *I. Niobrarensis*.† A costal bone of uncertain specific reference is abruptly expanded at the proximal end, indicating the narrowing of the adjacent one. Its proximal end is transversely truncate, and on the inferior side is a slightly-elevated and compressed capitulum, whose long axis is in that of the costal bone. The costo-vertebral scutal suture at the intervertebral scutal suture is but little inflected; the intervertebral is straight.

A vertebral bone picked up alone is wider than long; its form is subquadrate, with truncated angles and concave sides. The superior surface is smooth; on the middle line of the inferior is a longitudinal thin lamina, well produced downward, for suspension of the vertebra, resembling the arrangement I have shown to exist in *Stylemys*. This bone belonged to a tortoise of large size. It measures, length, $0^{m}.075$; width, $0^{m}.090$; thickness, $0^{m}.013$. In all the marginal bones preserved they are seen to be united with the costals by a squamosal suture, and in no instance by gomphosis.

The specimen which furnishes the characters of the *Testudo undata* includes portions or wholes of eight marginal bones and one costal. The former display a strong recurvature outward, and their internal thickening is near their sutural union with the costals. The borders are acute and do not display any emargination at either the dermal or osseous sutures. The posterior part of the margin of the posterior marginals is very convex or flared upward, descending at or behind the osseous suture. Thus the fore edge has an undulating form. The caudal marginal bone is recurved, not prominent, and with a regular entire free margin. Its lateral sutures expand forward, so that its margin is narrower than its anterior portion. It is not divided by dermal suture, consistently with the generic character. The surfaces of the bones are nearly smooth. The scutal sutures are wide, and have distinctly defined borders. The marginal near the bridge is remarkably massive; the bridgeward suture being twice as thick as that joining the free marginal.

The size of the *Testudo undata* is as great as that of any of the species of land-tortoises of our Tertiary formations.

Measurements.

	M.
Length of free margin of three consecutive posterior marginal bones	.310
Length of last marginal bone	.122
Width of last marginal bone	.135
Thickness at middle	.017
Thickness of bridgeward suture of a lateral marginal	.040
Thickness of opposite suture of same	.015

* Extinct Batrachia and Reptilia of North America, 1870, p. 123.

† Report of the United States Geological Survey of the Territories, (4to,) I, 225, tab. iii, fig. 4.

Fragments of other specimens, probably of this species, present still larger proportions.

As compared with the two described species of *Stylemys*, this species differs in the strong flaring and recurvature of its marginal bones, and in the more wedge-shaped caudal marginal bone, as well as its much larger size.

Testudo Klettiana, sp. nov.

Indicated especially by a caudal marginal bone of a tortoise of larger size than the one regarded as typical of the *T. undata*. It is, of course, probable that some of the fragments above described without especial reference belong to it. The caudal bone differs from that of *T. undata* in being nearly plane, and thus wanting the recurvature or superior concavity of the corresponding bone of that species. Its form is also quite different. Its lateral sutures are nearly parallel instead of divergent anteriorly, and slightly concave; if a little expanded proximally, it contracts again to the suture for the pygal bone. This suture is a short squamosal on the outside of the caudal. The thickness of the bone is almost uniform to near the proximal suture; there an abrupt rabbet commences the plane of the thinner pygal.

Measurements.

	M.
Width, proximal	.105
Width, distal	.110
Length	.110
Thickness	.019

The free margin is slightly convex.

Dedicated to Mr. Francis Klett, of the United States geographical survey, to whose interest in paleontology we are largely indebted for the opportunity of studying the vertebrate fauna of the Loup Fork beds of New Mexico.

GENERAL REMARKS.

The line of descent of the horses has been already largely traced by several paleontologists. Another series may now be regarded as partially completed, viz, that of the camels. I have already indicated the antecedent relation in which the Miocene genus *Poëbrotherium* stands to the existing camels in the structure of the limbs and teeth, as well as the intermediate position occupied by *Procamelus* in the existence of the incisor teeth. It now remains to point out the relations determined by the structure of the feet in *Procamelus*, and the dentition in *Pliauchenia*, as described in the preceding pages. Commencing with the earliest genus, *Poëbrotherium*, we have the molar teeth 4–3, as in the primitive *Mammalia* generally. There are but two elongate metacarpals, which are not united into a common bone; the lateral ones being rudimental, while the carpals are of the number characteristic of the *Mammalia* of all the orders with numerous toes; namely, seven. In *Procamelus* of the succeeding formation, the molar formula continues to be 4–3, but the posterior teeth are more prismatic in form than in the Miocene genus. The incisor teeth are present, thus displaying the primitive character of the class generally; though, as these teeth are early shed, an approximation to the edentulous condition existing in this part of the mouth of ruminants is apparent. In the feet, the approximation to the existing *Camelidæ* is greater than in the dentition. Thus the lateral rudimental metacarpals of *Poëbrotherium* have disappeared, and with them the trapezoides of the carpus. The magnum remains distinct, while the middle metacarpals are united at full age into a cannon bone. In the contemporary genus *Pliauchenia* a further modification of dentition is observed As above stated, the molars of *Procamelus* number $\frac{4\text{–}3}{4\text{–}3}$; in *Camelus* they number $\frac{3\text{–}3}{2\text{–}3}$; in *Pliauchenia* we have the intermediate condition $\frac{?\,4\text{–}3}{3\text{–}3}$. The end of the series is seen in *Auchenia*, where the formula is $\frac{2\text{–}3}{1\text{–}3}$.

It has been observed as a remarkable fact that North America should present us with the most complete history of the succession of genera which resulted in the horse, and yet should have received this animal by importation from Europe. Nevertheless, the more prominent genera of this series have been obtained in the European formations, especially *Auchitherium* and *Hippotherium*. But as regards the *Camelidæ*, the genera above described are exclusively North American; no well-determined form of this group having been found in any formation of the Palæarctic region up to the present time. Until such are discovered, there will be much ground for supposing that the camels of the Old World were derived from American ancestors; while the presence of the llamas in the existing South American fauna indicates the absence there of the conditions which caused their extermination from North America.

The *Mammalia* of the Santa Fé marls above described fall into the following orders:

	Species.
Carnivora	4
Artiodactyla	9
Perissodactyla	5
Proboscidia	1
Rodentia	3
Aves	3
Testudinata	2
Undetermined	2
	29

CHAPTER IV.

THE VALLEY OF THE RIO GRANDE FROM SANTA FÉ TO THE ZANDIA MOUNTAINS.

The country composed of the Santa Fé marls consists of bad-land tracts alternating with sage-brush plains. Near Santa Fé, the surface is worn into rounded hills. The level tracts are intersected by deep arroyos, (drainage-ravines;) and the bad-land tracts present the usual features of precipitous bluffs and buttes penetrated by cañons, or of low hills and naked terraces.

A short distance south of San Ildefonso, the Rio Grande again enters a cañon, which is caused by the presence of a horizontal bed of basalt covering the underlying Tertiary beds and protecting them from erosion. This cañon terminates the open valley which commences on the east side of the river some distance above the mouth of the Rio Chamra, and which has become the seat of a considerable population, in spite of the unfavorable character of its soil. Here are situated the Mexican towns of Playa Alcalde, Chalma, Santa Cruz, and Santa Fé, and the Pueblo Indian towns of San Juan, Santa Clara, Pojuaque, Coyamanque, nambe, San Ildefonso, and Tesuque.

Through the attention of General Gregg, commanding the District of New Mexico, I was furnished with means of transportatian southward as far as the Zandia Mountains. The country south of Santa Fé is level, the road passing over the basaltic plateau above described, which prevents exposure of the Tertiary beds. The surface is covered with sage, (*Artemesia*,) with other plants, a little grass, and two or three species of cacti, one of which is a subcylindric *Opuntia*, with broad white spines forming flat rosettes.

Descending into the valley of Galisteo Creek, which enters the Rio Grande thirty miles below San Ildefonso, the road passes over the upturned edges of the beds of the Cretaceous formation. They present escarpments toward the Rio Grande, dipping east and a little north 20°. The upper beds are of a yellow mud-color, and contain much cone-in-cone and some badly-preserved shells. The mud-beds include some strata of black carbonaceous shales, and the whole probably belongs to the Cretaceous No. 4. Below these, nearer to the creek, a series of harder slaty strata, including many *Inocerami*, appear, and these in turn are underlaid by about 300 feet or more of soft buff sandstones, which include occasional strata of carbonaceous slates. These form precipitous hills or bluffs along the course of the creek, and belong probably to No. 3. The thickness of the beds of Nos. 3 and 4, where crossed by the road, is about 500 feet. Below the buff sandstones, and apparently conformable with them, is a series of red sandstones of about 300 feet in thickness. I could find no fossils in them, and am uncertain as to their exact age. They form the Galisteo sandstone of Hayden, who regards them as peculiar to this region. These beds are further described below.

Opposite the mouth of the Galisteo, the bad lands of the Tertiary again appear, but are composed entirely of coarse gravel. The narrow valley of the Tuerto Creek, which enters the Rio Grande ten miles south, is bounded by similar hills of gravel, sometimes very coarse, resembling cobble-stones, and the same formation appears in hills between the town of Algodones and the Zandia Mountains. At San Felipe, the basalt bed disappears again from the eastern side of the Rio Grande, but caps the high bluffs on the western side. Beyond these, to the southwest of Algodones, red bad-land tracts are visible, which probably form a continuation of the Santa Fé marls.

A section carried across from the Rio Grande, at Algodones, to the Zandia Mountains, through the village and creek of Placita, gave the following results: The road winds among, and ascends for several miles, the mesas of coarse Tertiary gravel and cobble-stones until it reaches a wide plateau, from which the mountains rise on the east. This tract is traversed by Placita Creek and its tributary arroyos, which furnish interesting sections. From these it appears that the greater part of the plateau consists of the yellow muddy shales and sandstones of Cretaceous Nos. 4 and 3. They form the bottoms, and in some cases the walls of the arroyos, and rise in low monoclinal hills at various points on the plateau. The beds dip northwest 20° to 40°. In the intervals between the hills there is a deposit of indurated clay of 40 feet in thickness of post-Pliocene age. I obtained teeth and other bones of *Elephas primigenius*, sub-

species *columbi*, from this bed, and found bones of the same species in place in the banks of the arroyo. Shells of *Planorbis*, *Physa*, &c., indicated the lacustrine character of the deposit, which may be known as the Zandia clay. The Cretaceous No. 3, here, as on the Galisteo Creek, is underlaid by the red sandstones of the Galisteo group, which here dip 20° or more away from the mountains, close to the latter, north of the cañon, from which the Placita Creek issues. These beds constitute an important element in the landscape, as several lines of bare, rounded hills, whose red strata are curved and twisted so as to resemble at a distance low anticlinals. Immediately behind them, the Carboniferous limestone rises from beneath them. This formation, as has been already described by Professor Newberry, and previously by Prof. Marcou, constitutes the northeastern and eastern face of the Zandia Mountains, having evidently been tilted into its present position by the protrusion of a vast body of granite. The granite forms the precipitous southwestern and western escarpment of the mountain, displaying from this side its cap of Carboniferous limestone. This face is eroded into many gorges, leaving numerous irregular and picturesque peaks between them. The Carboniferous beds dip at an angle of 20° to the northeast. I obtained from them, on the sides of the cañon of the Placita, numerous fossils, including *Fenestella*, Crinoids, Brachiopods, *Acephala*, &c., which indicate the horizon to be that of the *Coal-Measures*. The total thickness of these beds is considerable; 1,000 feet being visible in the cañon, which does not penetrate them.

The age of the Galisteo sandstone is a point not satisfactorily decided. So far as their position on the flanks of the Zandia Mountains indicates, they may belong anywhere from Cretaceous No. 3 to the Coal-Measures. That they are not of Tertiary age, as has been supposed by some, is clear. Dr. Hayden's observations lead to the conclusion that they are not older than the Cretaceous, since he states that they overlie the coal of Placer Mountain, which itself is superior in position to undoubted Cretaceous beds. If these positions be correct, this group constitutes a special member of the Cretaceous formations.

The age of the volcanic outflow which has covered such extensive areas in the valley of the Rio Grande is more modern than that whose remains are seen in Central Colorado. Portions of the trachyte are there inclosed in beds of Miocene age, although the outflow of trachyte has covered the same beds at a later period. In the region observed by me, I noticed indications of three successive periods of eruption. The Loup Fork marls of the San Antonio

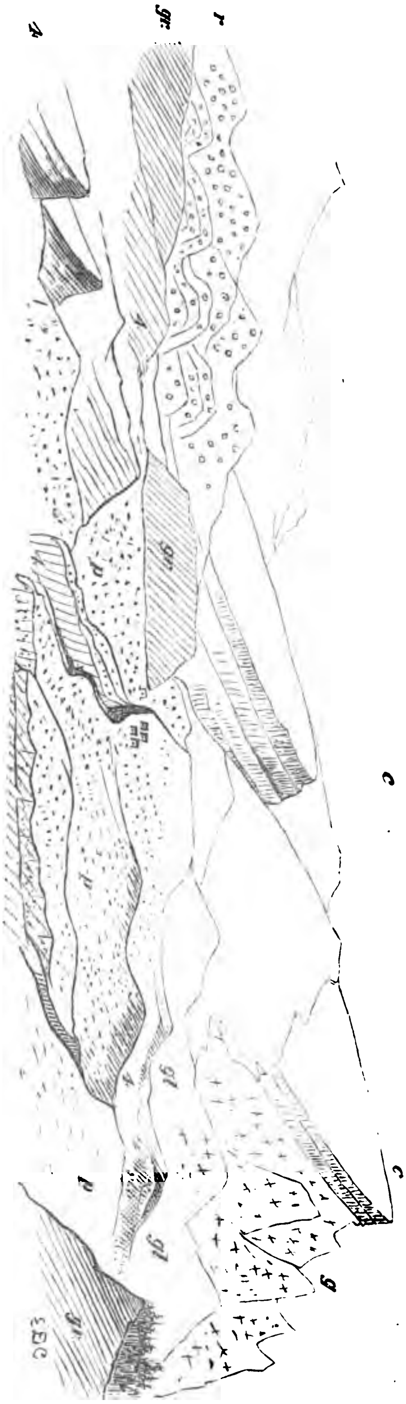


FIG. 3.—Diagrammatic sketch of the Zandia Mountains, looking east by south across the village of Placita; *g*, granite; *c*, Carboniferous limestone; *r*, red beds, looking like *gl*, Galisteo sandstone; *4*, Cretaceous Nos. 4 and 3; *p*, Placita marls; *gr*, gravel mesas.

Creek, near Conejos, contain pebbles of quartzite, sandstone, *trachyte*, and *basalt*, indicating the existence of the latter as rocks during the deposit of the marls. At other points I observed a horizon of basalt, intercalated with the arenaceous marly beds, while the third horizon is the usual one, capping the marls, and giving the mesa character to the region where it occurs.

CHAPTER V.

THE SIERRA MADRE AND ITS WESTERN SLOPE.

The close of the second chapter described the first appearance of the variegated red and yellow beds, as the exploration was carried from the valley of the Rio Grande to the dividing axis of the Sierra Madre.* As these strata rise, forming large hills on the north side of the Rio Chama, the road, rising less rapidly, passes over lower horizons, finally reaching a bed of hard, light, and rather coarse sandstone. At this point the route turns to the northward, leaving the river, and climbs a low, long hill, whose surface is this sandstone, without soil. A few miles beyond the summit is reached, and is found to present a sage-brush plane, many miles in extent, which is bordered by hills of remarkable beauty. To the south the caño nof the Chama with the Abiquiu Peak and other mountains beyond it bound the plane; while to the east and north, the brilliantly-colored strata above described form a perpendicular wall of about 500 feet elevation. The upper third or more of this precipice is of a lemon yellow, the remaining and lower portion of a subvermilion red, forming a beautiful combination. The rock is fissured by ravines, and intervening portions rise as huge buttresses of varied proportions, sometimes especially prominent near the summits, forming often regular bastions. Near the base certain bluish strata form naked mounds and hills of bad-land character; but I failed to discover any fossils on them. The southern face of this wall presents a tremendous fissure, the "puerta" of the Cañon Cangilon. Our route laid through this defile for many miles, and we thus obtained an excellent section of the higher level of the region.

The yellow beds of the present description were described at the close of chapter III, as being overlaid with a shale, and this again by an arenaceous conglomerate. These formations increase in thickness northward, and near the mouth of the cañon Cangilon a bed of fractured gypsum appears above the shale; the former soon becoming 25 feet in thickness, the latter only 3 feet. Along the sides of the southern part of the cañon the gypsum forms a snow-white bed of 50 feet in thickness, overlying the walls of yellow and red, and its borders are cut into fissures by the atmospheric erosion. From these points the stain produced by the dissolved gypsum forms stripes or fan-shaped shades of a beautiful mauve tint, which gives these rocky walls the appearance of a changeable silk, the mauve representing the shadows, and the red and yellow the lights. Altogether the picturesque forms, brilliant hues, and regular cleavage of the precipices which for miles bound this cañon form a scene of unusual beauty. The beds soon present a northwest dip. The gypsum descends from its elevated position, and a mud-brown sandstone appears on the summit of the walls. Six or seven miles beyond the mouth of the cañon, the gypsum bed is at the level of its bottom, forming low rounded hills at the base of the sandstone cliffs, (see Fig. 4,) which rise to a height of 700 feet. From this point the bottom of the cañon slowly rises between the sandstone walls, which, continuing their northwest dip, add perhaps 150 feet of thickness before the road reaches their summit-level. The road issues from the cañon on to an elevated country, which is covered with more grass than the regions previously traversed, and large patches of sage-brush. A short distance from this point a line of low hills runs parallel to the direction of travel, with a northwest and southeast strike. They support groves of piñones, and examination showed that they form the outcrop of the bed of Cretaceous No. 2, and doubtless rest immediately on the sandstone below. They consist of lead-colored shales, which whiten on exposure, and contain *Inoceramus* and *Ostrea* in abundance.

Having determined this horizon, I recur to those previously described, with the view of identifying them with the standard of comparison selected in chapter I, viz: the section at Colorado Springs. The resemblance is at once seen to amount to an identity. The sandstone of the northern half of the cañon Çanjelon is the Cretaceous No. 1; thickness 800 feet; below it the gypsum is that usually referred to the Jurassic, 50 feet, and doubtless inseparable from the brilliantly-colored beds below, (400 feet,) which undoubtedly belong to the Jurassic beds. The hard sandstone underlying these is the upper member of the beds that correspond to the Trias of the same section. Their

* The term "Sierra Madre" has been applied differently upon published maps of the Southwestern Territories. Its use is likely to be superseded as soon as the general topography of the several ranges and mountain groups shall have been determined.

thickness on the Chama was not determined. The feature of this section is the increased thickness of the beds of the Jurassic and Cretaceous No. 1.

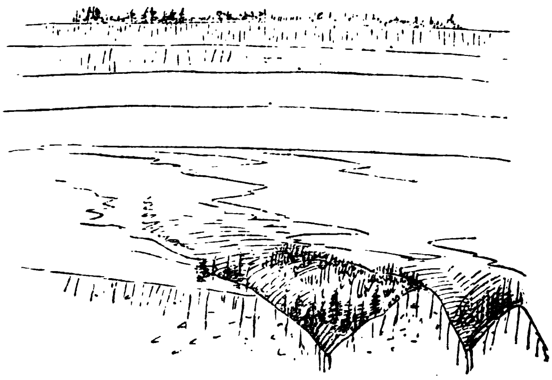


FIG. 4.—South wall of the cañon Can;elon: *c* 1, Cretaceous No. 1; *jg*, gypsum capping the "Jurassic."

Continuing the route, we reach a second line of low hills of yellowish soft sandstone with *Ostrea*, probably Cretaceous No. 3, and then descend into the shallow valley of Nutria Creek. From this point the level of the country rises to Tierra Amarilla, which was determined by the topographers to stand 7,480 feet above the sea. To the south and east of this town, high hills of yellowish sandstone present escarpments to the north, which are apparently Cretaceous No. 3, and contain numerous *Inocerami*. The Rio Chama flows two miles west of the town, in a south by west course, through a bed cut in the dark lead-colored shales of Cretaceous No. 2. Eight miles northeast an enormous vertical mass of rock rises abruptly 1,274 feet above the stream below its base, and is continued to the north and west in a less precipitous mountain-flank. This mass of rock is a landmark over a great extent of country; it is cleft to the base by the cañon of the Brazos Creek, one of the heads of the Chama. I took occasion on my return to traverse this upthrust, taking the trail which leads from Tierra Amarilla across the mountain-axis, of which it is the western border, to Conejos, on the edge of the Rio Grande Valley.

The road follows the course of the Brazos River, and for some distance the Cretaceous beds are in sight and nearly horizontal. Near the precipice above mentioned, these are lifted into high hills at an angle of 70° and 80°. On the north side of the river, sandstones of No. 1 rise with a similar dip, forming the foot-hills of the mountain, which rises perpendicularly to 1,500 feet. This mass is largely composed of a dense breccia of quartzite fragments, closely cemented into a uniform rock of a general pink color, and not variegated. Its characteristics and position refer it with probability to the Trias; but I could not detect any indication of the Jurassic beds between it and Cretaceous No. 1. After reaching the summit, we traversed the upturned edges of the formation, which have a strike varying from northwest and southeast to north and south. The elevated region now traversed by the trail is perhaps thirty miles in width, and is worn into rounded hills. The highest point indicated by the barometer is 10,400 feet. On the upper waters of the San Antonio Creek, high hills come into view, which have flat tops composed of a bed of trachyte, and their sides are often covered with pink and purple fragments of this rock. Within twenty miles of Conejos, the intervals between these hills are occupied by a heavy deposit of the Santa Fé marls, which, with masses of intrusive basalt rising in irregular masses, reminded us that we had once more reached the forbidding scenery of the Rio Grande Valley.

The bluffs that border the Chama near Tierra Amarilla are, as before observed, composed of the shales of No. 2, and they contain abundance of oysters and *Inocerami*. Near the upper part of the series, there are several thin beds of a light-brown color, containing numerous broken fish-bones and *Ostrea congesta*, &c.; the appearance resembling closely fish-bearing shales found by Professor Mudge near Stockton, Kans. From Tierra Amarilla, the route of my party lay southwestward. After crossing the river and the bluffs which bound its immediate valley five miles beyond it, the sandstone of Cretaceous No. 1 rises from beneath the Cretaceous No. 2 with a southeast dip. In some places, it rises abruptly like the wall of a fault, forming vertical bluffs of greater or less elevation, facing the east. This axis of elevation is at this point narrow, and the sandstone is soon found to dip to the southwest, west, and northwest. The route continued for forty miles along the western base of this line of elevation, which increases in importance as we proceed southward. A first, the Cretaceous No. 1 sand-

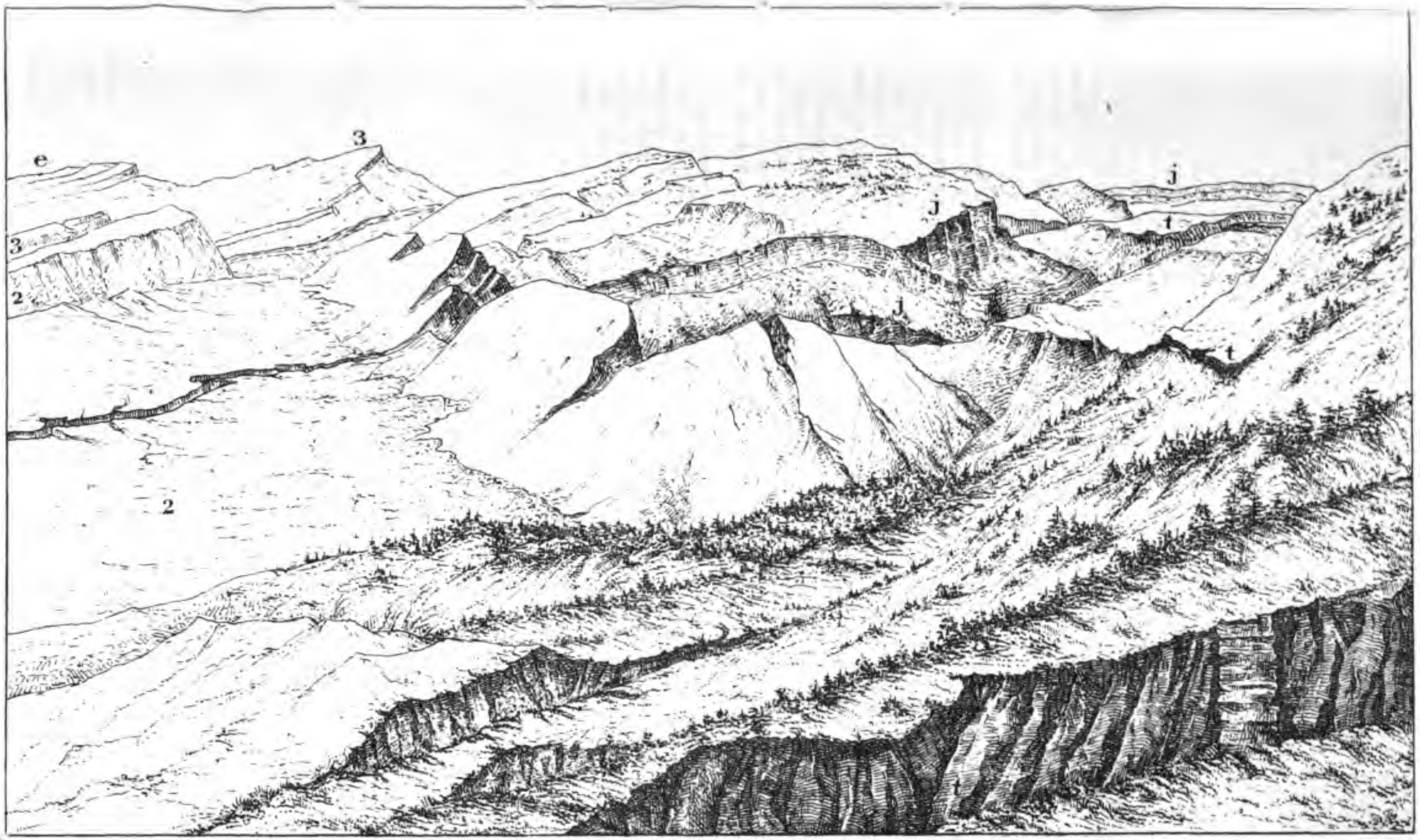
stone forms extensive barren slopes of 15° to 20°, constituting the northwest flank of the gradually-rising Gallinas Mountains; but farther south where the mountain reaches its greatest elevation, it is steeper and more broken.

The structure of the region west of the Sierra Madre from this point as far as my investigation extended (fifty miles) is a beautiful repetition of that observed and described on the east slope of the Rocky Mountains so far as the Mesozoic strata are concerned. The mountain-axis itself exhibits great variations in its surface-formation and elevation; but the position of the beds on its flanks is remarkably uniform. These form a series of hog-backs, formed by Cretaceous Nos. 1 and 3, and occasionally by harder beds of Nos. 2 and 4, which are separated by parallel valleys which are often grassed and timbered and rarely occupied by sage-brush. The most important of these is that lying between Nos. 1 and 3. The upper portion of the Chama flows through a similar valley on the eastern side of the Gallinas axis, and is turned aside by that line of elevation, and then cuts through the beds of No. 1 and the overlying formations, and finally through the axis of elevation farther eastward, reaching the Trias before entering the Santa Fé marls. On the western side of the axis of the Gallinas, the valley of Cretaceous No. 2 exhibits two points of elevation. The most northern is near the Rio Chama; the southern and highest, at the head of the Rio Puerco. From the latter the drainage is carried through the Gallinas Creek northward, which flows along the valley until it is turned aside by the rise toward the divide already mentioned, when it flows to the east through a cañon of the Gallinas Mountain and joins the Chama below.

The appearance of the No. 2 valley is as follows: On the left (east) the barren slopes of brown sandstone rise, marked with regular cleavage-lines, from which scattered piñones gain subsistence. On the east, perpendicular bluffs extend in a regular line, parallel with the mountain-axis. They reach 700 feet and more in height; but the strata are undulating in long waves, reaching the valley-level at intervals of several miles, where the depression opens a view of the country to the west. The face of the bluffs is the outcrop of the bluish shaly beds of No. 2, which are full of *Ostrea* and *Inoceramus*. The summit of the bluffs is the light-yellow sandstone of No. 3. This sandstone varies much in thickness, increasing toward the south, where it constitutes the entire bluff. The valley widens to the south for a distance, and a line of low hills of the shales of No. 2 rises from its surface. Another line of hills, less constant and less elevated than that of No. 3, is formed by the yellow beds of No. 4, and first appears near the mouth of the Gallinas Cañon, and continues to approach No. 3, until, to the south, the two combined form a single hog-back.

The axis of the Gallinas range appears to be undulating; at least, a series of undulations of the strata on its flanks are due to axes of elevation at right angles to the principal one. The side of the Gallinas Mountain at the north appears to be composed mainly of Cretaceous No. 1; but at the cañon of the Gallinas the colored beds of the Jurassic appear in its summits. South of this point these beds, capped with the white gypsum, extend entirely across the anticlinal; the sandstones of Cretaceous No. 1 appearing on the eastern as well as the western flank. Further south these are abruptly removed, leaving a plateau of the hard "Triassic" sandstone at a somewhat lower level, this bed resting in turn on the deep-red marls of the same age. Farther south the Triassic sandstone forms the summit of the highest line of the range; the Jurassic and Cretaceous No. 1 reposing on its sides. Still farther south the Nacimiento Mountain rises to a greater height, and is composed of the red feldspar-porphyry of the Rocky Mountain axis. It forms the culmination of the Sierra Madre, and extends southward as far as my examination was carried.

The first and most northern section (Plate III) was carried across the flank of the mountain twelve miles south of the entrance of the cañon of the Gallinas Creek. The oldest beds of this section form a plateau surrounded by greater elevations, from which it is separated on the south and east sides at least by deep ravines. The walls of these are composed of a deep-red marl of the Trias, capped by the usual heavy bed of gray sandstone. The north side of this plateau is bounded by an abrupt precipice of Jurassic strata, the red below, yellow in the middle, and the bed of snowy gypsum on top; the relations of the Triassic and Jurassic here being precisely as described above at the entrance of the cañon Canjelon. The sandstones of Cretaceous No. 1 are observed on both east and west flanks of this open anticlinal; on the eastern side without the intervention of the gypsum bed. The yellow bed is also deeply scored, and in some places isolated, showing that a stronger eroding action had been at work on this side than on the west prior to the deposit of the Cretaceous No. 1. Immediately to the west of the plateau, a more elevated wave is also covered with the Jurassic beds; the entire summit of the mountain for many miles being composed of the gypsum. This soft material is worn into innumerable gullies. It is separated from the plateau by a gorge, which is the seat of a fault. The Triassic plateau has evidently been thrust upward so as to continue the level of the yellow beds of the Jurassic at this point, the fault thus amounting to not more than three hundred feet. But the Jurassic beds dip southward, forming the descending slope of a longitudinal wave of their axis of elevation. As the Triassic is level at the point of descent



View taken from the Western flank of the Gallinas Mountains looking north.

t Triassic strata.
j Jurassic do.
1 Cretaceous N° 1.
2. Cretaceous N° 2.
3. Cretaceous N° 3.
e. Eocene

of the Jurassic gypsum to the valley-level, the fault amounts to a thousand feet. At the junction of the two, the evidence of faulting is to be seen in the vertical

FIG. 5.—View of a "Jurassic" anticlinal, looking north: *g*, Gallinas Creek; *j*, Jurassic beds, composed, from above downward, of the white gypsum, the yellow, and the red beds; 1, Cretaceous No. 1, sandstone; 3, Cretaceous No. 3, in the distance.

escarpments of the middle bed of Triassic sandstone, which is here on edge with the deep-red marls on both east and west sides of it. The gypsum does not descend to the valley-level, however; the end of the anticlinal having been cut transversely by a line of drainage, marked in summer by a deep arroyo, (Fig. 5.) Immediately to the west, the sandstone of Cretaceous No. 1 forms the usual line of hog-backs, but at this point it does not lie immediately on the Jurassic, the softer lower beds having been cut out by the passage of the Gallinas Creek. This stream cuts through the hog-back escaping from the valley of No. 2, and returns to it again, after pursuing a short course between No. 1 and the gypsum. Southward five miles, the Triassic beds with the sandstone cap have been lifted to a greater elevation, of at least 1,000 feet above the level of the Gallinas. This has naturally been accompanied with a greater lateral extension. In Plate III, the foreground consists of its red beds and intercalated sandstones which extend to the valley of the Gallinas; the Jurassic beds being undiscoverable on its flanks, and even Cretaceous No. 1 being lost for a short distance. This projection or angle is opposite to an isolated mass of this formation, which, in the absence of another name, I called Red Peak. The area of the Trias is concentric with its base, the boundary retiring eastward on the south side. Here the Jurassic beds re-appear, the gypsum standing vertical, and forming a line of narrow, steep hills; the lower beds are not visible, but form the bottom of a valley which separates the Jurassic hills from the mountain. The relation of the two formations is here clearly seen, (Fig. 6.) The elevation of the red peak and adjacent mountain-axis has fractured the Triassic beds, so that the upper sandstone, which is horizontal on their summits, also lies at a steep angle (45°) on their southwestern flanks. An interesting example of curved strike is here exhibited. The tilted sandstone at the left of Fig. 7 strikes northwest and southeast; the same ledge in the middle foreground north and south. These beds lie immediately on the blood-red Triassic marls, as in the mountains and elsewhere.

Two miles south the Jurassic and Cretaceous No. 1 beds disappear through the erosion of a drainage-valley, but south of the latter the Jurassic rises steeply, with a dip northwest 25°, to an elevation of 700 feet above the valley. The upper surface is composed exclusively of the gypsum, and the eastern is precipitous, exhibiting the usual three strata of white, yellow, and red in descending order. But below these appear the deep-red marls of the Trias, which occupy the valley separating the Jurassic hill from the Trias mountain, and form a body of Triassic bad lands. The surface of this tract is eroded into cañons, ravines, and arroyos, with irregular masses of a deep-red color between them. Perhaps three-quarters of a mile separates the vertical sides of the valley; the Triassic beds forming the eastern wall, with the marl below and a very heavy bed of hard sandstone on top, rising to 900 feet by barometer. In the bad-land tract I obtained satisfactory evidence of the lacustrine character of the formation, a point of much importance, inasmuch as the character of these beds has remained very obscure up to the present time. The evidence consists of numerous specimens of species of *Unio* from a number of distinct localities, and fragments of bones and teeth of two or three species of Saurians, one of which at least is of terrestrial habits, according to our present knowledge. I have submitted the *Unios* to my friend Mr. F. B. Meek, who informs me that they belong to three species, which he describes as follows:

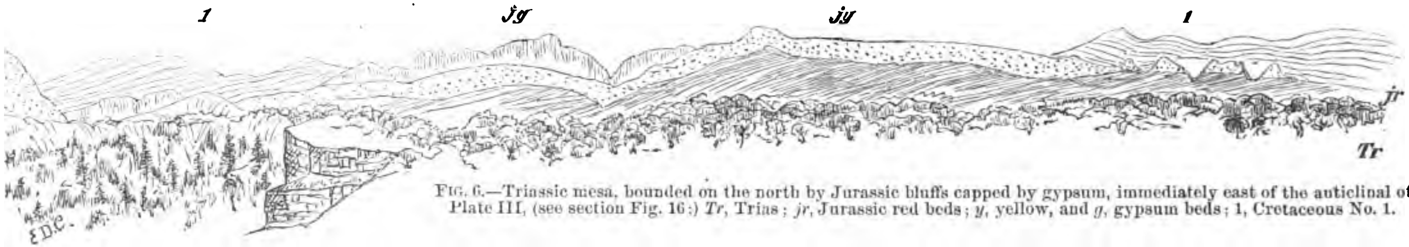


FIG. 6.—Triassic mesa, bounded on the north by Jurassic bluffs capped by gypsum, immediately east of the anticlinal of Plate III, (see section Fig. 16:) *Tr*, Trias; *jr*, Jurassic red beds; *y*, yellow, and *g*, gypsum beds; 1, Cretaceous No. 1.

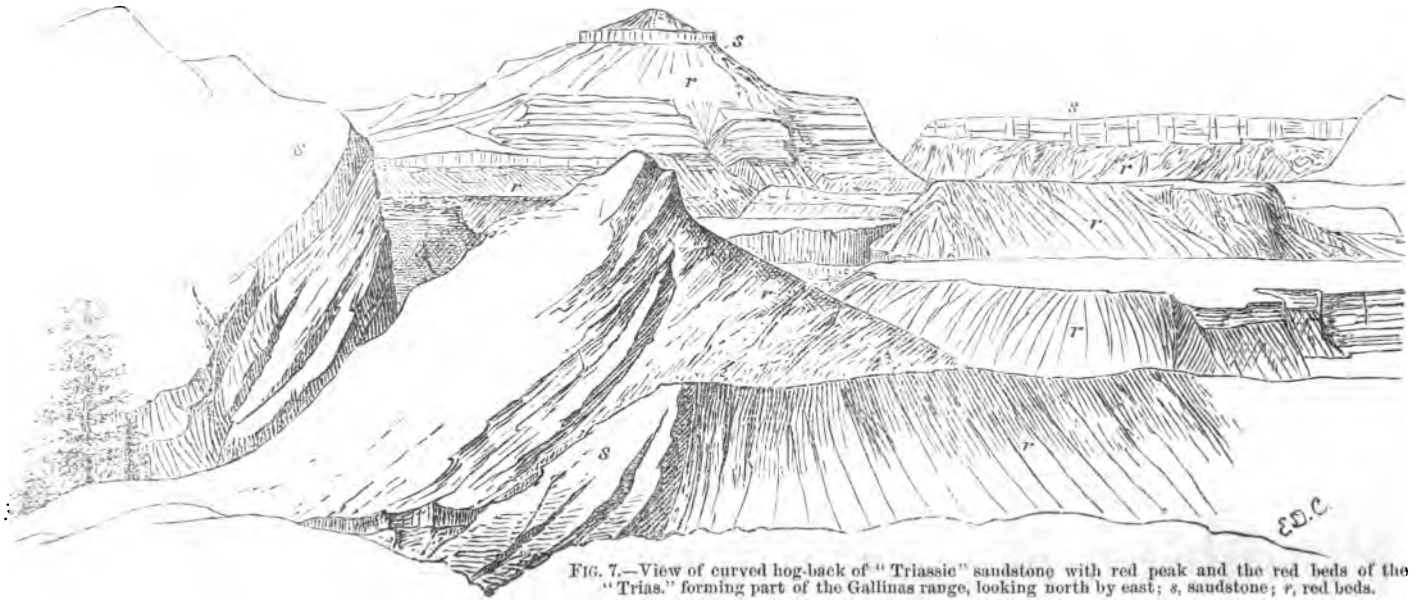


FIG. 7.—View of curved hog-back of "Triassic" sandstone with red peak and the red beds of the "Trias," forming part of the Gallinas range, looking north by east; *s*, sandstone; *r*, red beds.

"UNIO CRISTONENSIS, Meek.

"Shell under medium size, transversely ovate, thick, and strong, moderately convex; anterior outline rounded; posterior more narrowly rounded, and more prominent below than above the middle; basal margin semi-ovate; flank usually with a slight flattening or very faint concavity, extending from the umbonal region downward; beaks depressed, and placed about half-way between the middle and the front; surface with more or less distinct marks of growth, but without costæ, tubercles, or other ornamentation; hinge rather strong; anterior teeth more or less furrowed, that of the left valve deeply bifid, and that of the right sometimes a little emarginated; lateral teeth apparently of moderate length; muscular scars deeply impressed, particularly the anterior, which are very close to the anterior margin, and usually have one or two or more little irregular denticulations just above, directly under the anterior division of the cardinal tooth.

"As near as can be determined from the fragmentary specimens, the dimensions of one of the largest would be about as follows: Length, 1.65 inches; height, 1.10 inches; convexity, 0.70 inch.

"The only specimens of this species found are very imperfect; and, from that fact and their general similarity to Tertiary forms, of which many much better specimens have been brought in from the Far West, I paid but little attention to them when they were sent to me by Professor Cope without any indications of their age. I wrote to him that the form here described resembled *U. Haydeni*, from the Bridger group (Tertiary) of Wyoming; but, as a caution against too hastily adopting this suggestion as a settled conclusion, I added, 'you can readily understand, however, how very difficult it would be, in this genus, to identify allied living species from the examination of mere battered and broken odd valves, picked up along the shores of our western rivers.'

"Soon after writing as above I received a letter from Professor Cope, informing me that these specimens came from Triassic beds. This, of course, caused me to examine them more closely; and, on doing so, I find that the form most nearly like *U. Haydeni* in size, form, and proportions, as well as in surface-markings, still differs in having a slight flattening (already mentioned) down the flanks under the beaks. I think its posterior dorsal outline is also a little more declining, or, in other words, not quite so straight and horizontal as in *U. Haydeni*. I know very little of the hinge of *U. Haydeni*, but its anterior teeth seem to be different, so far as can be seen, from those of the form under consideration, which also has its valves more thickened internally in front of the middle, and sometimes provided with a low internal ridge, corresponding to the external slight flattening of the valves.

FIG. 8.—Bad lands of the "Trias" looking southeast; the Jurassic and Triassic beds on opposite sides of a fault: *ts*, Triassic sandstone; *tr*, Triassic red beds; *jg*, gypsum beds of the Jurassic; *jy*, Yellow beds of the Jurassic.

"The similarity of this species to *U. Haydeni* is another evidence of the fact (to which I have often called attention) that fresh-water shells, as a rule, are far less reliable guides than marine types in identifying formations, since they often closely resemble each other from widely different horizons.

"Along with the foregoing there are fragments of several other species, too imperfect to be well characterized. One of these has more prominent and curved beaks, with small, radiated costæ. I have not usually attempted to name species from such imperfect specimens; but as Professor Cope desires to have some names by which these interesting types may be designated, I would propose for this form with the more gibbous beaks and small radiating costæ the name *U. Gallinensis*.

"Still another species is also represented in the collection by fragments. This evidently differs from the last by having much more depressed, more oblique, and less gibbous beaks, and stronger radiating costæ, only seen on the posterior dorsal region, at least in the specimen examined. This might be called *U. terræ-rubræ*.

"There is also another more compressed form, with depressed beaks and flattened or concave flanks, resembling the first-described species (*U. Cristonensis*,) but showing fine radiating costæ, in one example on the beaks only, and in another apparently over most of the valve.

"Supposing that these shells really come from the horizon of the Trias, they are the oldest *Unios* yet found, so far as I am informed, in this country."

The remains of *Vertebrata* obtained from the latter formation are those of fishes and reptiles. The former are rhomboganoid scales of small species, which are numerous in the coprolites of the reptiles; the latter represent the three orders of *Crocodilia, Dinosauria*, and apparently of *Sauropterygia*. The dinosaurian order is represented by a part of the crown of a tooth of a species of large size of the general character of *Lælaps*. Both faces are convex, the one more so than the other, and the long axis of the crown is curved toward the less convex side. Both cutting-edges are sharply and closely crenate-denticulate, as in *Lælaps, Aublysodon*, &c.; otherwise, the enamel is perfectly smooth. There was not enough of this animal discovered to enable me to identify it. The suspected sauropterygian species is represented by a single vertebra, with the centrum slightly depressed, circular section, and about as long as wide. The neurapophysis appears to have been united by suture, although this point is not so clear as is desirable, and the bases of the diapophysis are very stout, extending the entire length of the upper half of the lateral surface of the centrum. Of the articular faces, one is much more concave than the other. Length of centrum, $0^{m}.05$; width, $0^{m}.057$; depth, $0^{m}.055$. The crocodilian remains consist of a portion of a jaw-bone, with alveoli for four teeth, of a broken vertebra, and a number of dermal scuta and fragments of other bones; at another locality not far distant, numerous remains of saurian bones, embracing dermal and cranial pieces, coprolites, a fragmentary tooth, &c., which may have some affinity to these. The species indicated by the former may be named and described as follows:

TYPOTHORAX COCCINARUM, Cope, *genus et species nova*.

Character genericus.—The fragment of jaw belonging to this genus is probably maxillary in position, for the following reasons: The interior face of the bone is sutural, and for the most part solid. This would refer it to the position of the symphyseal portion of the dentary bone of a gavial-like form, but for other considerations. Supposing the piece to be dentary, and the suture therefore vertical, the incongruity follows that the alveolar face becomes very steep, so much so as to prevent the interlocking of the teeth, which become lateral in position. If, however, the jaw-fragment be reversed in position, and the alveolar face placed in a horizontal position, the suture of the inner side forms a sharp angle with the vertical plane, as it should on the supposition of its being the maxillary bone; the wedge-shaped section necessary to fill the space between it and the median plane, being that of the prolonged posterior spine of the premaxillary bone. The solidity of this portion of the muzzle is inconsistent with the gavial genera of the Jura and later times, but not with the structure of the Triassic Belodons. The posterior part of the inner face is, however, strongly excavated, and the sutural margin exhibits an outward deflection, which is either the boundary of the nostril or the suture for the apex of the prefrontal or nasal bone. In either case, the nareal cavity and the nostril are posterior in position, in conformity with the structure of the "mecodont" *Crocodilia*. The alveoli are large and arranged in a curved line; one of them somewhat exterior in position and isolated by short diastemata, like a canine. Surface of the bone pitted. The dermal scuta found close to the jaw-fragment have flat upper surface marked with shallow pits, rather closely placed, having resemblance to an obsolete *Trionyx* sculpture. Near one of the margins of the bone, the pits run out in shallow grooves. A portion of a vertebral centrum found with the jaw exhibits one articular face; this is shallow concave, of the type of the amphicoelian division of *Crocodilia*. The body of the centrum is much compressed.

The other remains include a portion of a dermal bone like those described, and the crown of a tooth, among other fragments. This crown, which has lost most of its en-

amel, is triangular in section, and somewhat curved in its long axis. A convex face is directed forward and outward, (on the supposition that the tooth is superior,) and a nearly plane face posteriorly. The inner face is worn flat by the attrition of an opposing tooth. The pulp-cavity is minute or wanting.

Char. specif.—The pitting of the maxillary bone is not linear, and is sometimes round; it is rather remote. The outside of the bone is steep, indicating that the muzzle is not depressed. Its face is swollen opposite the supposed canine tooth. The alveolæ are round and longitudinally oval. The alveolar face is decurved near the end of the muzzle. The superficial layer of the cranial and dermal bones is dense and fine-grained. The second series of specimens, whose reference is by no means certain, but which contains a dermal bone like that of the type, includes fragments apparently of the upper surface of the cranium. This is marked with irregular tuberosities and excavations resembling that seen in the *Belodonta* of the Carolinian and Würtembergian Trias. A section of a narrow, dermal bone displays an elevated, obtuse, median keel, the only one which displays this form in the collection, the usual form being either flat or slightly concave. Accompanying the same are numerous coprolites, which are apparently too small for an animal of the dimensions of the type-specimen. They are slender, and display rectal folds, which do not display a continuous spiral. They are found, wherever fractured, to be filled with the rhomboganoid scales of some small fish.

Measurements.

		M.
Length of fragment of maxillary		.095
Depth (oblique) at nostril (?)		.050
Depth (vertical) at nostril (?)		.045
Width (median) at nostril (?)		.025
Width at front alveolus		.035
Diameter of canine alveolus		.015
Diameter of another alveolus		.011
Diameter of centrum of (? caudal) vertebræ	transverse	.024
	vertical	.022
Thickness of dermal shield		.008
Measurement across four fossæ		.020
Diameter of crown of tooth No. 2		.018
Length of coprolite of No. 2		.045
Diameter of coprolite of No. 2		.011

The flat and regularly-pitted dermal shields distinguish this genus from *Belodon*. The species was of large size; the cranial fragments equalling corresponding portions of the Gangetic Gavial.

The evidence derived from the *Typothorax coccinarum* is favorable to the identification of this horizon with that of the Trias, although it cannot, of course, be regarded as conclusive until more perfect specimens are obtained.

Besides the overlying sandstone bed, the red marls are traversed below it by a conglomerate, which is in some places of a bluish tint. At some points, it weathers to gravel, and near this horizon the vertebrate remains occur. At other points, it forms a very hard Potomac marble, containing pebbles of various colors. Near the same level I obtained specimens of impure copper-ore, which simulate petrified wood in form. The sandstones, especially those lying obliquely on the mountain-side, (Fig. 7,) I found to contain obscure vegetable remains, some of which are replaced by oxide of iron. They reminded me of similar remains observed in the same horizon near Taos.

On passing a mile to the south of the locality which has been described, the opposite masses of the Jurassic and Triassic rocks are seen to descend at an angle of 20° and 25° to the south, marking the terminus of another longitudinal wave of the axis, of which the one immediately to the north has been described in connection with Fig. 5. The valley caused by this descent is the drainage-axis of the Upper Gallinas Creek, which issues from the mountains at this point. This locality is instructive as furnishing the third example of the fault existing between the Triassic and Jurassic rocks, already illustrated in Figs. 6 and 16. The Triassic sandstone is also faulted at several points at right angles to the principal fault, as seen in the north and south escarpment, (Fig. 9.) The fragments of the fractured sandstone-bed strew the west slope of the Triassic mountain, and disappear in the red marls.

From this depression the mountain rises gradually first in a lower ridge and then to the long and regular crest of the Nacimiento Mountain, (Fig. 10.) The axis of this new elevation forms an open angle with that of the range of the Gallinas proper, running northeast and southwest, the consequence of which is a change of strike of all the elevated beds on its flanks. The Cretaceous hog-backs make a very regular angle in their direction; its apex being the point of change of axis at the cove I have described above in detail. At the same time, the hog-backs approach nearer to the mountains, and the variegated and gypsum beds of the Jurassic are not

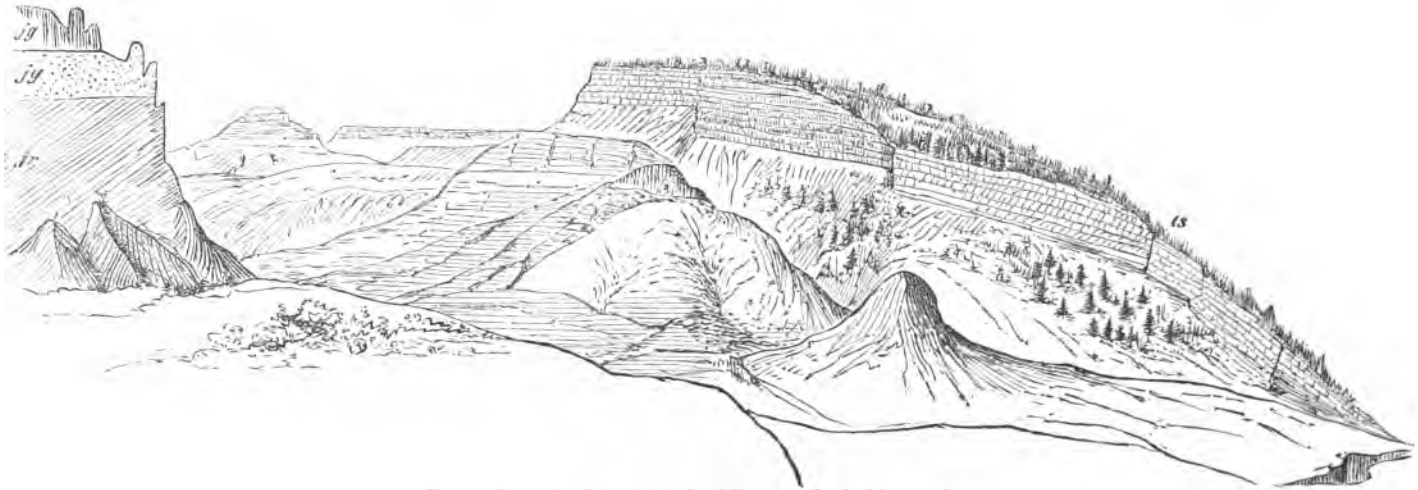


FIG. 9.—View of "Triassic" beds of Figs. 7 and 8, looking northeast.

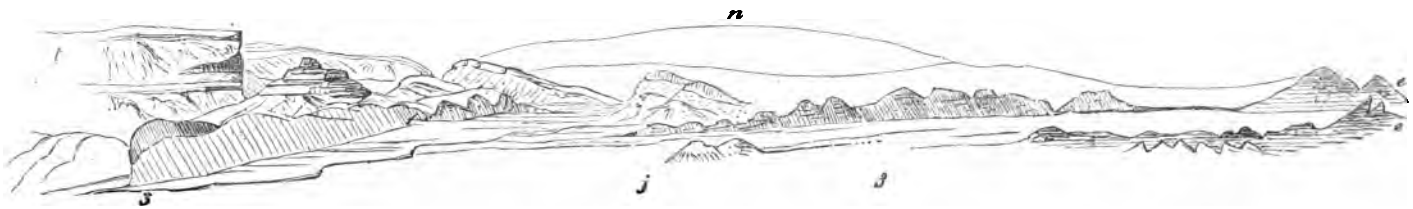


FIG. 10.—View of Nacimiento and adjacent mountains, looking southeast from the Eocene bluffs; *t*, Trias, (Gallinas Mountains;) *j*, Jurassic; 3, Cretaceous Nos. 3 and 4; *c*, Eocene; *n*, Nacimiento Mountains.

seen. The southward route passes over the divide which separates the drainage of the Gallinas from that of the Puerco. South of this divide the Cretaceous beds, including their highest members, Nos. 3 and 4, disappear on the sides of the Nacimiento Mountain. The mountain itself is the feldspathic porphyry of the true Rocky Range axis, which, rising through the Mesozoic beds which cap the northern part of the Sierra Madre forms its most elevated portion. At the village of Nacimiento, the red Triassic beds are visible on the mountain-side, and its upper sandstone dips south as well as west from an elevated position. The range extends south from this point as far as my observation reached. The valley is occupied in localities near the mountains with the red feldspathic gravel usual along the Rocky Ranges. Some of the Mexicans spoke of copper-mines, with ancient stone buildings, in the ravines of the Nacimiento.

I conclude this chapter by a little further allusion to the Cretaceous hog-back, of which the most important is that formed by No. 3. At one of the depressions in this line (Fig. 11,) the erosion has displayed a considerable bed of lignite. It appears in four beds, which are represented in the following section:

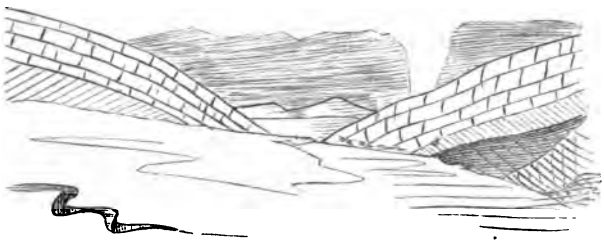


FIG. 11.—Synclinal in Cretaceous No. 3, opposite the Cañoncito de las Vegas.

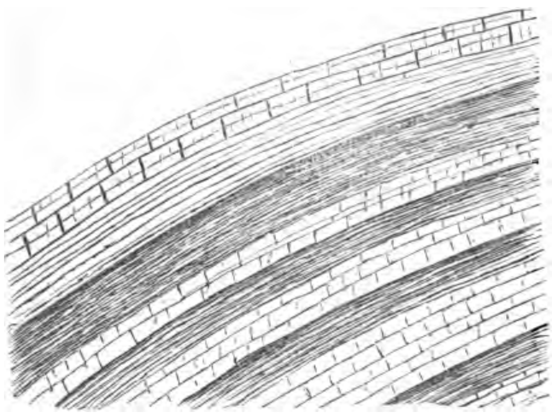


FIG. 12.—Section of Cretaceous No. 3 at locality of Fig. 11.

	Feet.
Sandstone No. 3	00
Limonite	$2\frac{1}{2}$
Carbonaceous shale	10
Lignite	10
Sandstone	00
Lignite	3
Sandstone	00
Lignite	3
Sandstone	00
Lignite	3
Total	80

This lignite bed extends throughout the region west of the Rocky Mountains wherever No. 3 occurs, and is the bed which has been mistaken for the true lignite, or No.

6, by some geologists. It appears in this horizon wherever access is obtained, but is generally impure and of little or no value. Ten miles south of this point the following section exhibits it, (Fig. 13.) The beds differ in thickness at different localities; their

FIG. 13.—Hog-back and lignite of Cretaceous Nos. 3 and 4 at Cristone, looking south.

combined mass, with rather thin layers of slate, at one point reaching 50 feet. At the locality of Fig. 13, it is overlaid by a heavy bed of yellow sandstone, from which I obtained teeth of sharks of the species *Oxyrhina?* and *Galeocerdo pristodontus*, Agass. These yellow beds are traversed for a mile to two miles west of the hog-back of Cretaceous No. 3, forming lines of low hills, from which I obtained numerous fossil *Mollusca*. These include *Baculites*, *Ammonites* of two species, including *A. placenta*, *Inoceramus*, and a number of well-preserved *Dimyaria* and *Gastropoda*. On this account, I suppose these beds to represent Cretaceous No. 4.

A portion of their lowest member lies on the hard portion of No. 3 at some points, as already stated, forming the upper part of the hog-back; at least, I obtained the *Baculites*, an *Ammonite*, and the usual form of *Inoceramus* from such a locality. The two horizons are separated by the lignite, and, when this is eroded, a double line of hog-backs as in Plate IV. This sketch was taken from the southern extremity of the hog-back of No. 3, of which the northern extremity is represented in the left-hand ledge of Fig. 13. The direction of view is to the southward. A hog-back of No. 4 is seen on the right, and the double hog-back, chiefly of No. 3, is in front of the observer. To the left horizon appear the southwestern slopes of the Nacimiento Mountain. The right horizon is occupied by the horizontal beds of the Eocene, and an arroyo which drains their slope pursues its way into the Gallinas Creek, which comes into view from the left hand. Immediately in front of its valley is a lower hill of Cretaceous No. 3, on whose summit stands a large stone building, one of the many which strew the crests of all these hog-backs. An account of these is given in my report on archæology. Further observations on the Cretaceous beds are deferred until the Eocene deposits are considered.

CHAPTER VI.

THE EOCENE PLATEAU.

West of the hog-back of Cretaceous No. 3, at an interval of perhaps two miles, at a point just north of the Gallinas Mountain, a sandstone bluff presents a bold escarpment to the northeast. This is the angle of a mass of rock whose eastern face extends southward parallel to the mountain-axis, and whose strata dip first 15° then 10° south, and soon disappear beneath a similar mass. This series also presents an escarpment to the northeast, and its beds also dip 10° south, nearly opposite the cañon of the Gallinas. This façade rises to from 600 to 900 feet elevation, and is cleft to the base by a deep gorge, the Cañoncita de las Vegas. I traversed this fissure, passing entirely through to the elevated country to the westward. Six miles from its mouth is a large pool, fed by a spring known as the Mare's Spring. The cañon is narrow, and the walls almost perpendicular. They are composed of the "puerta," or entrance, of a moderately hard, reddish-brown sandstone. The cañon is twenty miles in length, its bottom has a gentle rise; and as the sandstone has a gentle dip toward the west as well as south, its upper beds reach the level of the bottom at about the middle of the length of the cañon. Above them softer beds appear, alternating with strata of sandstone; the beds are first gray, but others soon appear which are striped with red. The red-striped marls increase in relative thickness toward the west, and the sandstone strata diminish until at the head of the cañon the high lands fall off in masses of hills of bright-colored marls eroded into rounded and picturesquely-formed hills. These extend in a long line to the

View from ruin N°1. Cristona, looking South.

3. Cretaceous N°3. c Cretaceous. g Gallinas Creek.
4. Cretaceous N°4. n Base of Nacimiento Mountain. r Ruins of Cristona
e Eocene. a Arroya

north and the south, facing westward. To the west, a wide, elevated plain spread before us, varied with a few hills, and stretching away with a gentle slope to Cañon Largo and the country of the San Juan River. The discovery of the variegated marls was one of no little interest to the writer, inasmuch as I had made special efforts to find Eocene beds in this region, and they were now crowned with success. The position of these marls, with their close physical resemblance to the Wahsatch beds of Bear River, Wyoming, together with the evidence furnished by a lower molar of *Bathmodon*, discovered by my guide, indicated that I had discovered the sediments of the great body of fresh water which during successive stages of the Eocene period occupied the drainage-basin of the Great Western Colorado. The thickness of the strata exhibited in the walls of the Cañoncita de las Vegas I estimated at 1,200 feet.

On leaving the mouth of this cañon, and proceeding southward, the southern dip of the red sandstones brings their summit to the ground-level in about ten miles distance, (see Fig. 14.) The red and gray marls with alternating beds of white and yellowish sandstone appear on their summits, and at a point twenty miles south of the cañon form a mass of bad-land bluffs of from 600 to 1,000 feet elevation. This escarpment retreats and then turns to the east, forming an extensive horseshoe, the circumscribed area being occupied with hills and picturesque masses of sediment, with all the peculiar forms and desolation of bad-land scenery. I remained in camp for about a month near this circle, and obtained many fossil remains of *Vertebrata.** Ten miles south of this point another horseshoe of bad lands covers an extensive area, and proved to be as rich in fossil remains as the first. Here I made my second camp, remaining in it for three weeks. The southern boundary of the northern tract extends to within six miles of the Cretaceous hog-backs, while the corresponding part of the second approaches nearer, forming a line of bluffs of considerable height running north and south parallel with, and half a mile from, the hog-backs. Beyond the Puerco divide, hills of this formation rise on both sides of the trail, and near the Ojo de San José, the Eocene beds repose on the foot of the Nacimiento Mountain several miles to the east.

Below the sandstones which form the portals of the Cañoncita de las Vegas, another stratum of marls shows itself in hills of 100 feet and higher, in the sage-brush plain that separates them from the Cretaceons hog-backs. They are soft and of mixed black and dark-green colors near the locality in question, and capped by light and yellowish sandstones. These are the lowest beds of the Eocene, and I traced them for forty miles to the south along the belt of country intervening between Cretaceous No. 4 and the reddish sandstone. At the locality just mentioned they conform to the sandstones above, having a dip of 10° southwest, while they do not conform to the hog-back of Cretaceous No. 3, the nearest available outcrop, which dips at 25° west. Farther south this marl is represented by low hills of generally lighter color. Near Nacimiento it has an increased importance, as it rises both to the east and south. The valley of the Upper Puerco is excavated in it for some distance, and its blackish, greenish, and gray hills are seen on both sides of the river. At a point on the river about six miles below the village of Nacimiento, the lower sandstone of the Eocene forms a perpendicular bluff, which terminates in an escarpment of 500 feet elevation facing the south. The red-striped marls, having acquired a gentle northern dip, disappear from view some miles to the north, and the termination of the underlying sandstones warned us that we were approaching the southern border of the basin.

The border of the sandstone turned to the west at this point, the line of bluffs continuing as far as vision extended. Below and south of it the varied green and gray marls formed the material of the country, forming bad-land tracts of considerable extent and utter barrenness. They formed conical hills and flat meadows, intersected by deep arroyos, whose perpendicular walls constituted a great impediment to our progress. During the days of my examination of the region, heavy showers of rain fell, filling the arroyos with rushing torrents, and displaying a peculiar character of this marl when wet. It became slippery, resembling soap in consistence, so that the hills were climbed with difficulty, and on the levels the horses' feet sank at every step. The material is so easily transported that the drainage-channels are cut to a great depth, and the Puerco River becomes the receptacle of great quantities of slimy-looking mud. Its unctuous appearance resembles strongly soft-soap, hence the name *Puerco*, muddy. These soft marls cover a belt of some miles in width, and continue at the foot of another line of sandstone bluffs, which bound the immediate valley of the Puerco to a point eighteen miles below Nacimiento. Here the sandstone again turns to the westward, presenting a southern escarpment of 500 to 1,000 feet elevation. This forms the southern boundary of the Eocene basin. I could not be sure whether this sandstone is identical with that of the escarpment twelve miles north, but suspected it to be such. Immediately south of it, low hills of Cretaceous No. 4 extend across the Puerco and continue south of the Eocene bluffs at a distance of a mile or two with a

* See Report on Fossil Vertebrata of New Mexico; An. Rept. Chief of Engrs., 1874, and Systematic Catalogue of Vertebrata of the Eocene of New Mexico, 1875, 8vo, Geographical Explorations and Surveys West of the One hundredth Meridian, Lieut. G. M. Wheeler.

FIG. 14.—View from hog-back of Cretaceous No. 3, from ruin No. 1, looking west-northwest toward the bluffs of the Eocene.

FIG. 15.—Eocene bad-land butte looking south from camp No. 2.

FIG. 16.—View of the Eocene bad lands, looking north from the second camp west of the Gallinas.

western strike. They were as elsewhere of a soft yellowish sand and clay, including shale beds, and contained abundance of *Inoceramus*, like those found on the Gallinas.

Ten miles to the southward, the underlying Cretaceous beds are capped by a horizontal table of basalt, thus forming a mesa, through which the Puerco passed in a cañon. I supposed this to be the forerunner of the great basaltic plateau, which, according to Lieutenant Wheeler, constitutes the country south of the Rio Chaco for a great distance, one of little promise to the agriculturist. These tracts are known as the Mesa Fachada and Mesa de los Lobos. The season being well advanced, (October 22,) I thought best to commence the return march, which we accordingly did.

The soapy marls, or, as they may be called, the Puerco marls, have their principal development at this locality. I examined them throughout the forty miles of outcrop which I observed for fossil remains, but succeeded in finding nothing but petrified wood. This is abundant in the region of the Gallinas, and includes silicified fragments of dicotyledonous and palm trees. On the Puerco, portions of trunks and limbs are strewn on the hills and ravines; in some localities the mass of fragments indicating the place where some large tree had broken up. At one point east of the river I found the stump of a dicotyledonous tree which measured 5 feet in diameter.

As already remarked, the Puerco marls belong to the Eocene series in their strict conformability to the superincumbent rocks of that age. They do not appear to represent the Fort Union or Lignite beds of Northern Colorado and the North, as they differ in almost every respect. They contain no lignite nor coal, although their occasional black color may be due to a small amount of carbonaceous matter. They have no resemblance to the Fort Union beds in mineral character or fossils. I conclude, as a result of the investigation, that the latter formation has no existence in this part of New Mexico. The presence of such quantities of petrified wood gives weight to the probability that the Puerco marls are a lacustrine formation. In exploring the hills of this formation along the Puerco, I found the horns of an elk, (*Cervus canadensis.*) This locality must be near the southern limit of its range. I learned that it is not uncommon on the high plateau near Tierra Amarilla on the northeast.

I made a second section of the upper or Green River beds to the west, starting from opposite the middle of the northern bad-land cove. About the middle of the marl series there is usually present a bed of nearly white sandstone, frequently quite hard, in which the fossils have generally a worn or rolled appearance. Here occurred the greater number of the sharks' teeth. but not all. Above this horizon the most abundant fossils are the gars and crocodiles, while the greater number of the mammals

FIG. 17.—Bad lands of the Wahsatch beds near camp No. 2.

come from below it; but this distinction is of a very general character. On climbing the western escarpment of these marls, the summit is found to be a plain sloping at a

slight angle to the south and west. Escarpments composed of the upper beds of marl and sandstones extend mostly in east and west lines.

The most important of these is, first, an outcrop of sandstone, ten miles west of the bluffs. Here I found characteristic fossils. The trail follows a cañada, or narrow shallow valley, for perhaps forty miles. Branches pass to the right and left between the hills, affording beautiful park-like views. The drainage of this Eocene plateau from the summits of its eastern escarpment is to the west, reaching the San Juan River by Cañon Largo and Cañon Amarillo. Along the cañada, the marls re-appear; their red and gray colors contrasting with alternating beds of sandstone. These sink, and are followed by a soft, yellow sandstone, which forms the face of the Gabilan Hill, eighteen miles west of the bad lands. Other bad lands appear beyond; the sandstone resting on them. For many miles, the alternating marls and sandstones form steep hills on each side, of 100 to 300 feet elevation, until about thirty miles west of the Gallinas bad lands they terminate in bold headlands, the escarpment of the formation sweeping right and left to the north and to the south. From high, bold hills they drop off in lower terraces, and the general level of the country slopes more rapidly to the west. From this point a fine view toward the cañons of the San Juan is had over a descending plain studded with irregular hills. A low table-land, perhaps forty miles distant, is deeply notched at two points, which my guide, who is familiar with the region, termed the Puertas, or Gates of the Cañons Largo and Amarillo, with the Mesa de Chaco to the left. The point on which we camped is termed on the maps the Alto del Utah, and is placed at 6,648 feet elevation, although there are more elevated hills nearer to the bad-land façade of the Gallinas. The entire region is devoid of springs, but covered with grass and good timber. The entire region is a favorite resort for the shepherds, with large flocks from the valley of the Rio Grande, in winter; otherwise, it is without resident inhabitants. Myself and guide depended on pools of water of a rain which had fallen a week or more previously, and found it palatable, although muddy. In several of them I found young individuals of *Spea stagnolis*, Cope, with their tadpoles, which had evidently had but a short time for incubation, metamorphosis, &c. As usual in this group, the tadpoles attain a large size before changing. I found also on a number of the bad-land hills, as far as the Alto del Utah, pottery of the ancient people who appear to have once inhabited this country in large numbers. An account of these is reserved for a special chapter.

The following list includes the species of fossil vertebrates discovered in the horizon of the Green River Eocene above described:

QUADRUMANA.

PELYCODUS, Cope.

Pelycodus Jarrovii, Cope, Eocene Vertebrata, Geogl. Ex. and Surv. W. of 10th M., 1875, p. 14.
Pelycodus frugivorus, Cope, l. c., 14.
Pelycodus angulatus, Cope, l. c., 14.

PANTOLESTES, Cope.

Pantolestes Chacensis, Cope, l. c., 15.

SARCOLEMON, Cope.

Sarcolemur mentalis, Cope, l. c., p. 17.
Sarcolemur crassus, Cope, l. c., p. 17.

HYOPSODUS, Leidy.

Hyopsodus miticulus, Cope, Report on Vertebrata of New Mexico, An. Rept. Chief of Engrs., p. 596.
Hyopsodus ? paulus, Leidy.

APHELISCUS, Cope.

Apheliscus insidiosus, Cope, Report on Vertebrata of New Mexico, An. Rept. Chief of Engrs., 1874, p. 602.

INCERTÆ, SEDIS.

OPISTHOTOMUS, Cope.

Opisthotomus astutus, Cope, Eocene Vertebrata, Geogl. Ex. and Surv. W. of 100th M., 1875, p. 16.
Opisthotomus flagrans, Cope, l. c., p. 16.

OLIGOTOMUS, Cope; *Orotherium*, Marsh, not of Aymard.

Oligotomus vintanus, Marsh.

PHENACODUS, Cope.

Phenacodus primævus, Cope, Report on Vertebrata of New Mexico, An. Rept. Chief of Engrs., 1874, p. 598.
Phenacodus omnivorus, Cope, l. c., p. 598.
Phenacodus sulcatus, Cope, l. c., p, 599.

CARNIVORA.

AMBLOCTONUS, Cope.

Ambloctonus sinosus, Cope, Vertebrata Eocene, Geogl. Ex. and Surv. West of 100th M., 1875, p. 8.

OXYÆNA, Cope.

Oxyæna morsitans, Cope, Report on Vertebrata of New Mexico, An. Rept. Chief of Engrs., 1874, p. 600.
Oxyæna lupina, Cope, l. c., p. 599.
Oxyæna forcipata, Cope, l. c., p. 600.

PROTOTOMUS, Cope.

Prototomus viverrinus, Cope, l. c., p. 601.
Prototomus secundarius, Cope, Vertebrata of the Eocene, Geogl. Ex. and Surv. W. of 100th M., 1875, p. 9.
Prototomus multicuspis, Cope, l. c., p. 10.
Prototomus strenuus, Cope, l. c., p. 10.

PACHYÆNA, Cope.

Pachyæna ossifraga, Cope, Report on Vertebrata of New Mexico, An. Rept. Chief of Engrs., 1874, p 601.

DIDYMICTIS, Cope.

Didymictis protenus, Cope, l. c., p. 602.

DIACODON, Cope.

Diacodon alticuspis, Cope, Vertebrata of Eocene, Geogl. Ex. and Surv. W. of 100th M., 1875, p. 12.
Diacodon celatus, Cope, l. c., p. 12.

PERISSODACTYLA.

OROHIPPUS, Marsh.

Orohippus cuspidatus, Cope, Vertebrata of Eocene, Geogl. Ex. and Surv. W. of 100 M., 1875, p. 22.
Orohippus agilis, Marsh.
Orohippus procyonimus, Cope.
Orohippus angustidens, Cope, l. c., p. 22.
Orohippus major, Marsh.
Orohippus vasacciensis, Cope.
Orohippus tapirinus, Cope, l. c., p. 20.

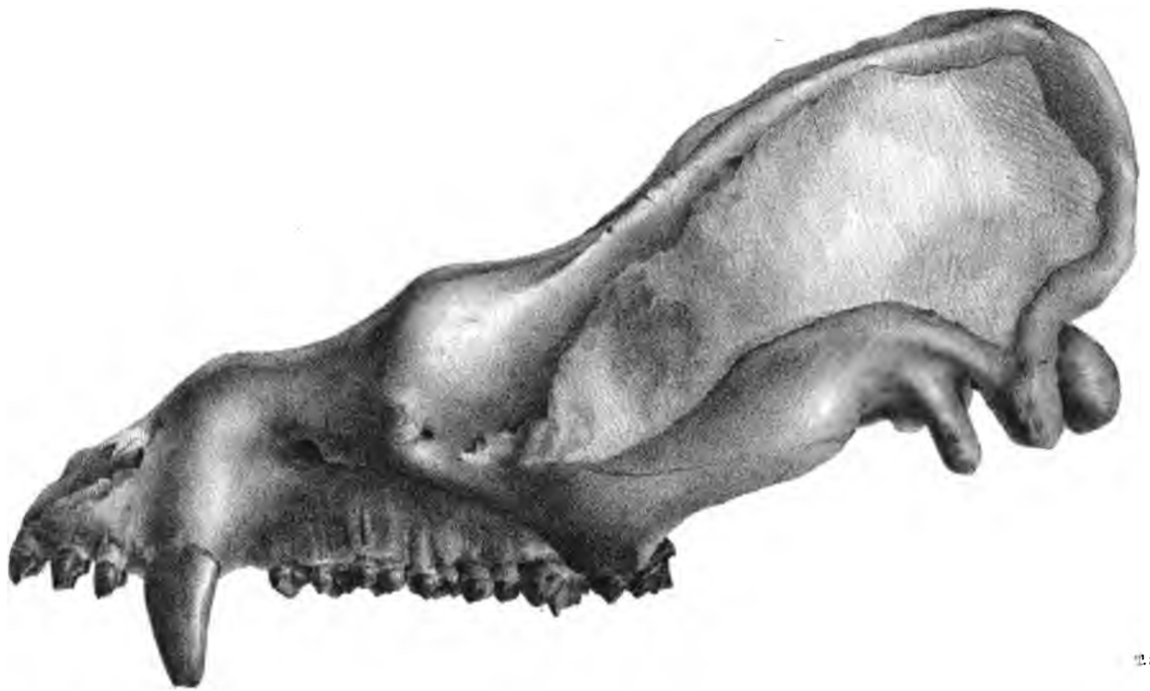
HYRACHYUS, Leidy.

Hyrachyus singularis, Cope, l. c., p. 19.

MENISCOTHERIUM, Cope.

Meniscotherium Chamense, Cope, Report on Vertebrata of New Mexico, An. Rept. Chief of Engrs., 1874, p. 596.

PLATE V.

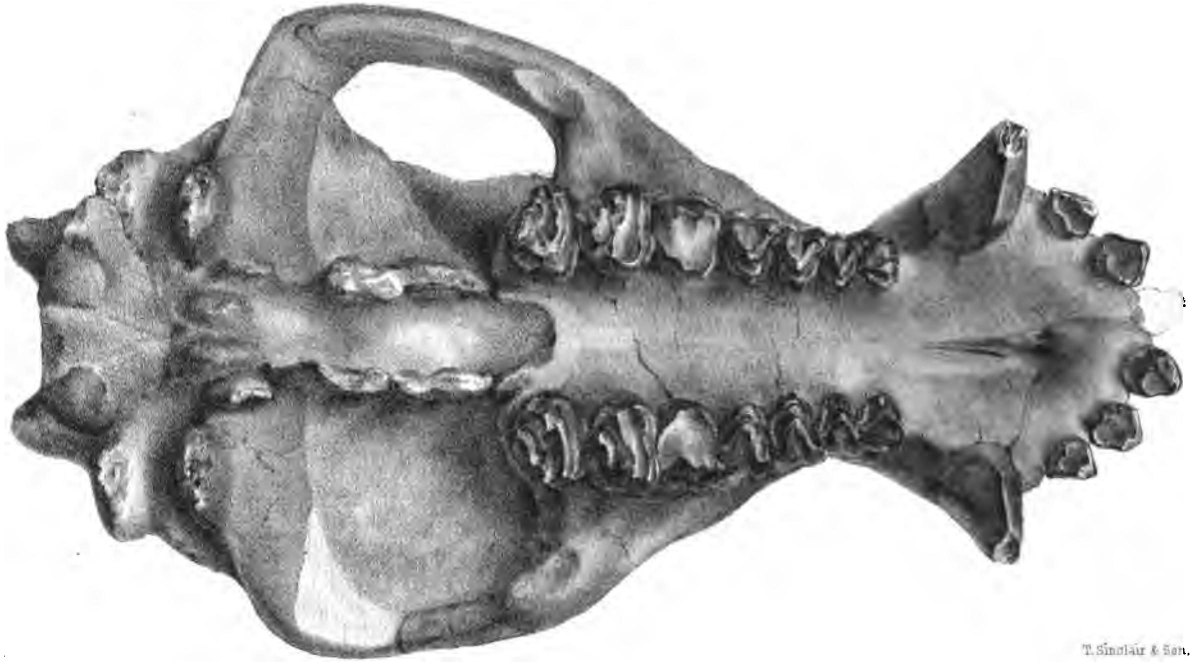


E. C. Beaux.

T. Sinclair & Son, lith. Phila.

BATHMODON ELEPHANTOPUS, CRANIUM, SIDE VIEW. 1/3
FROM THE GALLINAS.

PLATE VI.



E. C. Beaux

T. Sinclair & Son, lith. Phila.

BATHMODON ELEPHANTOPUS, CRANIUM, FROM BELOW. 1/3
FROM THE GALLINAS.

? TOXODONTIA.

ESTHONYX, Cope.

Esthonyx bisulcatus, Cope, Report on Vertebrata of New Mex'co, An. Rept. Chief of Engrs., 1874, p. 594.
Esthonyx Burmeisterii, Cope, l. c., p. 595.

ECTOGANUS, Cope.

Ectoganus gliriformis, Cope, l. c., p. 592.

CALAMODON, Cope.

Calamodon simplex, Cope, l. c., p. 593.
Calamodon arcamœnus, Cope, l. c., p. 593.
Calamodon Novomehicanus, Cope, l. c., p. 594.

AMBLYPODA.

BATHMODON, Cope.

Bathmodon molestus, Cope, l. c., p. 597.
Bathmodon lomas, Cope, l. c., p. 597.
Bathmodon simus, Cope, l. c. p. 596.
Bathmodon elephantopus, Cope, l. c., p. 597.
Bathmodon radians, Cope, Vertebrata of Eocene, Geogl. Ex. and Surv. W. of 100th M., 1875, p. 29.
Bathmodon latidens, Cope, l. c., p. 29.
Bathmodon cuspidatus, Cope, l. c., p. 30.

RODENTIA.

PARAMYS, Leidy.

Paramys delicatissimus, Leidy.
Paramys delicatior, Leidy.

CROCODILIA.

DIPLOCYNODUS, Pomel.

Diplocynodus spenops, Cope, Vertebrata of Eocene, Geogl. Ex. and Surv. W. of 100th M., 1875, p. 31.

CROCODILUS, Linn.

Crocodilus grypus, Cope, l. c., p. 32.
Crocodilus veelerii, Cope, l. c., p. 33.
Crocodilus ? elliotii, Leidy.
Crocodilus ? liodon, Marsh.
Crocodilus Chamensis, Cope, Report on Vertebrata of New Mexico, An. Rept. Chief of Engrs., 1874, p. 603.
Crocodilus heterodon, Cope.

LACERTILIA.

GLYPTOSAURUS, Marsh.

Glyptosaurus, sp. indet.

TESTUDINATA.

TRIONYX, Geoffr.

Trionyx Uintaensis, Leidy.
Trionyx radulus, Cope, Vertebrata of Eocene, Geogl. Ex. and Surv. W. of 100th M., 1875, p. 35.
Trionyx cariosus, Cope, l. c., p. 35.
Trionyx leptomitus, Cope, l. c., p. 35.

FIG. 18.—Section nearly east and west from the Gallinas to the Eocene bluffs. Horizontal scale about an inch to two miles. *t*, Triassic: *s*, sandstone; *r*, red beds. *j*, Jurassic: *g*, gypsum; *y*, yellow bed; *r*, red bed. 1, Cretaceous No. 1; 2, Cretaceous No. 2; 3, Cretaceous No. 3; 4, Cretaceous No. 4; *p*, Puerco marls; *e*, Eocene sandstone; *g*, Gallinas Creek; *l*, Lignite.

PLASTOMENUS, Cope.

Plastomenus corrugatus, Cope, l. c., p. 35.
Plastomenus fractus, Cope, l. c., p. 35.
Plastomenus catenatus, Cope, l. c., p. 35.
Plastomenus communis, Cope, l. c., p. 35.
Plastomenus lachrymalis, Cope, Report on Vertebrata of New Mexico, Am. Report Chief of Engrs., 1874, p. 603.
Plastomenus Thomasii, Cope.

BÆNA, Leidy.

Bæna arenosa, Leidy.

DERMATEMYS, Gray.

Dermatemys costilatus, Cope, Vertebrata of Eocene, Geogl. Ex. and Surv. W. of 100th M., 1875, p. 36.

EMYS, Broug.

Emys latilabiatus, Cope.
Emys Stevensonianus, Cope.

HADRIANUS, Cope.

Hadrianus Corsonii, Leidy.

PISCES.

CLASTES, Cope.

Clastes, sp. indet.

LAMNA, Cuv.

Lamna Texana, Roemer.
Lamna, sp. indet.

OXYRHINA, Ag.

Oxyrhina, sp. indet.

GALEOCERDO, M. H.

Galeocerdo pristodontus, Ag.
Galeocerdo ? adencus, Ag.

CARCHARODON, Ag.

Carcharodon, sp. indet.

In review, I give the following section of the Eocene rocks of the region west of the Sierra Madre:

	Feet.
Red and gray marls, Green River group	1,500
Sandstone, Green River group	1,000
Green and black marls, Puerco group	500
Total	3,000

The following is an approximate estimate of the Mesozoic beds in the same region. As they were not accurately measured, the numbers will have to undergo revision. Their relative thickness is nearly as given.

	Feet.
Uncertain, concealed in the sage-plain	500
Cretaceous No. 4	1,500
Cretaceous No. 3	400
Cretaceous No. 2	1,500
Cretaceous No. 1	500
Jurassic	600
"Trias" (bottom not seen)	1,000
Total	6,000

The Mesozoic beds of this section (excepting some of the higher members of the Cretaceous) have been examined over extensive areas to the west and south by Messrs

Marcou and Newberry, whose valuable reports accompany those of Lieutenants Whipple and Ives, on the routes surveyed by them through Arizona and New Mexico. The horizon here termed after Hayden "Triassic" has been referred previously to this formation by Professor Marcou also, who had the opportunity of examining it in Texas and the Indian Territory. So far as the latter region is concerned, I can confirm the identification, having examined bones from the red beds of that country which appear to be those of Belodonts. Dr. Newberry terms it in Arizona the "salt group," or "saliferous sandstones," referring to it as probably including both Triassic and Permian strata. The formations here called Jurassic are partially included by Professor Marcou in his Triassic series, and are termed by Dr. Newberry the "variegated marls," who is inclined to refer them to the Jurassic.

APPENDIX G 2.

GEOLOGICAL AND MINERALOGICAL REPORT ON PORTIONS OF COLORADO AND NEW MEXICO, BY DR. O. LOEW, MINERALOGIST AND CHEMIST.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE
ONE HUNDREDTH MERIDIAN,
Washington, D. C., April 22, 1875.

SIR: I have the honor to submit herewith a report upon the agricultural resources and geological structure of those portions of Southern Colorado and Northern New Mexico that were traversed by party No. 2, division 2, to which I was attached in the season of 1874.

Special attention was given to the examination of the chemical composition of rocks, soils, and minerals, a subject too often neglected.

Collections were made of all the rocks and minerals mentioned in this report, and the preparation of a separate list is not deemed necessary.

Very respectfully, your obedient servant,

O. LOEW,
Mineralogical Assistant.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

CONTENTS.

The Valley of the Arkansas River—The Sierra Mojada and Sangre de Cristo Mountains—The Gray Back Placers—Cerro Blanco San Juan range—Composition of basalt from Abiquiu—The mountain region of Abiquiu—Analysis of a zeolite—The Nacimiento Desert—Analysis of a sandstone—Analysis of the garnets of Fort Defiance—Analysis of chrysolite from Fort Defiance—From Mount Taylor to the Placer Mountains—Analysis of turquoise from Los Cerillos—The mountains between Santa Fé and Las Vegas—Analysis of hydraulic limestone from Las Vegas—Analysis of a green feldspar from Bear Creek—Climatological notes—Temperature of rivers and creeks.

THE VALLEY OF THE ARKANSAS RIVER AT PUEBLO, COLORADO.

The cretaceous strata, everywhere conspicuous along the base of the main Rocky Mountain range, and forming the principal body of the adjoining plains, are well exposed in the channel which the Arkansas River has formed. The limestones, with their characteristic shells, among which is *Inoceramus* in great numbers and large size, the sandstones, the clays, the slates, and the coals, in short, all varieties of sedimentary deposits, are met with, as well as their manifold transitions, as calcareous sandstone, arenaceous limestone, argillaceous lime, and sandstones, &c. The limestone frequently contains particles and lumps of iron pyrites, incrusted with rust, an occurrence I have noticed also with the cretaceous limestones at Las Vegas, N. Mex. The sandstones occur in a number of localities—for instance, five miles above Pueblo—are fine-grained, of great uniformity, and in demand, a great deal being shipped to Chicago for building purposes.

There is no coal in the immediate vicinity of Pueblo, as far as I could ascertain, but farther up are a number of beds; for instance, at Carlisle, a farm twenty miles above Pueblo, there is exposed a seam of bituminous coal 6 inches thick, overlaid by strata of sandstones and shales to a height of more than 40 feet. Thick beds of coal are found farther up the river near Cañon City; also mineral oil. An analysis of the coal has

been given in a previous report. A mile below Pueblo a bed of about 50 feet in thickness is exposed, which consists in alternate layers of gypsum and clay, each nearly a fifth to a third of an inch in thickness. Now, if we consider the periods during which the clay or mud was deposited as the rainy seasons, in which the streams carried much muddy water from the mountains into the neighboring shallow sea, and the following deposition of gypsum as the result of the waters being clear and more concentrated, as would be the case in a dry season, or in summer, we then have for each alternate layer, one year, and for the deposition of the bed of 50 feet, a period of twelve hundred years. The position of the strata along the valley has not been disturbed by violent action like volcanic eruption, &c., and therefore occupy a horizontal position. Here and there, however, singular bends are observed in the strata, the limestone layers being slightly curved. Another irregularity is, that I observed, four miles above Pueblo, the deposits appearing as though formed under peculiar influences, as currents or motions of some kind. These irregularities, however, cover but a small area, the neighboring strata being quite regular.

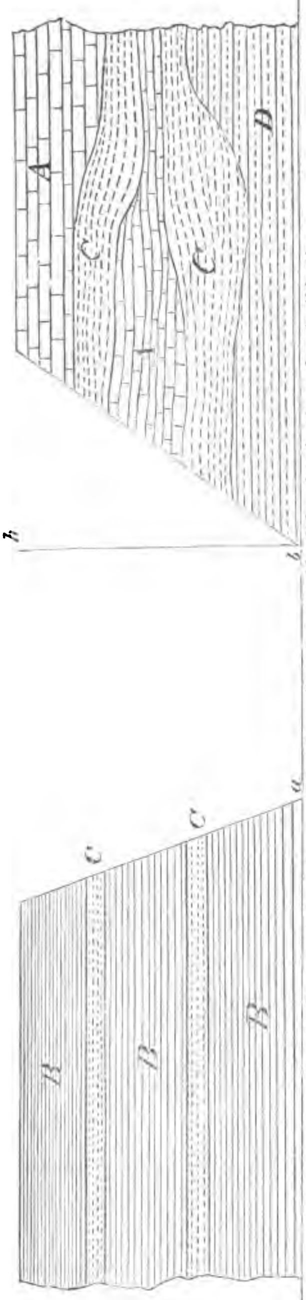


FIG. 1.—Section of the Arkansas Valley five miles above Pueblo, Colo., showing irregular stratification.

This figure represents a section of the Arkansas Valley, five miles above Pueblo, Colo., which shows irregular stratification. A, sandstone; D, sandstone interstratified with slate; C, slate; B, limestone. Distance *a b* = 200 yards; height C H = 30 feet. Here and there white efflorescences are noticed in the valley of the Arkansas. These, on examination, were found to consist of sulphate and chloride of sodium. A number of mineral springs occur in this section—one at Carlisle, and more than half a dozen at Cañon City—descriptions of which, with analyses, were given in a former report. The water of all wells sunk in the valley is gypsiferous—usually called in this section "alkaline water." Whether or not the use of this water will prove beneficial to health is yet to be seen. Here and there the slopes of the Arkansas Valley are densely covered with drift and bowlders of no small size.

THE SIERRA MOJADA AND SANGRE DE CRISTO MOUNTAINS.

The Sierra Mojada (also called Cuerno verde range and Greenhorn Mountains, at least as far as its southern portion is concerned) is nearly parallel for fifty miles with the Sangre de Cristo Mountains, and thus is formed a long valley between the two chains, which is drained by a number of creeks. The most northern portion of this depression is known by the name of "Wet Mountain Valley," while descending in a southerly direction we have the valley of the Muddy and that of the Huerfano, (Huerfano Park.) The Sangre de Cristo Mountains are joined on the west side by a wide, plain-like valley, the San Luis, while the Sierra Mojada forms the western boundary of the great plains of Southeastern Colorado. Where the plains approach the mountain range a great number of trachytic dikes protrude through the sedimentary strata. Where the mountains die out in the plains, the strata of the cretaceous epoch occupy the field almost exclusively, while between the foot-hills of the mountains carboniferous rocks are exposed. The chief mass of the mountains, however, is composed of azoic rocks. These masses of granites and gneisses are full of volcanic dikes. Near the junction of the Saint Charles and Green-

horn Creeks, on the eastern slopes of the Sierra Mojada, the limestone beds are exceedingly rich in cretaceous shells. Calcite occurs also in very large crystals. From the head of Greenhorn Creek to that of the Red Creek, a bed of conglomerate of great thickness extends, which, near the head of the latter, consists of granules of feldspar and quartz, with here and there particles of muscovite. The cementing substance is a reddish clay, and the quartz-pebbles present a rounded appearance as though worn considerably. The beds of this conglomerate dip 20° to 22°.

Some ten miles west of Red Creek, the Hardscrabble Creek, another tributary of the Arkansas, leaves the mountains. There may be seen quite a number of interesting phenomena due to glacial action; morainal deposits, polished quartz, rocks, and scattered bowlders testify to former glacial phenomena of grandeur and magnitude. The cañon of Hardscrabble Creek is formed on both sides by sandstone strata, which dip 60° to 70°. The declivities thus formed are perfectly barren, although the valley immediately beneath is covered with a vigorous forest vegetation. The barrenness of these declivities, however, is not due to climatic influences, but solely to their great inclination, whereby the soil is prevented from taking hold.

Crossing the crest of this northern portion of the Greenhorn Mountains we descend to the recent mining town of Rosita. As regards the silver-mines of this section, the reader is referred to vol. I of the quarto series of reports. We only allude to them here as regards their geological position. The Victoria and Senator lodes are true fissure-veins of galeniferous quartzite in the trachytic porphyry, while the others, northwest of these, are chiefly situated in sedimentary rocks.

Clay strata containing particles of chloride of silver form quite extensive beds. These sedimentary deposits have a considerable dip—30° to 45°—a result produced by the disturbances which accompanied the later volcanic eruptions in the vicinity. Slides are also noticed in several instances; one of 25 feet occurs on the Victoria lode.

A mile southwest of Rosita, on the southern slope of a hill covered with quartzitic *débris*, are masses of round siliceous concretions, from the size of a nut to that of a human head, scattered about profusely. These the miners call "petrified heads," defining the contortions here and there upon the globes as the brain turned into stone. At a glance we may recognize in them the results of siliceous waters formerly existing here, results analagous to the deposits and incrustations observed with the siliceous geysers of Montana and Idaho. No clue as to the extent and position of these hot springs can at present be found in Wet Mountain Valley, time having covered up their former sites by the rubbish of the ages. Passing a little farther south, over a low, hilly country, with mighty mountain chains on either side, we reach the head of the Muddy, a tributary of the Huerfano River. While sandstone predominates at this point, a few miles to the westward, between the neighboring foot-hills of the Sangre de Cristo Mountains, we meet with syenite and amphibolite, and on the Cuerno verde Peak, to the southwest, with syenitic granite. This peak is an interesting structure. Its lower portions are covered with sandstone, then follows granite, the top being formed by volcanic masses. Fifteen miles to the south of the head of the Muddy we cross the Huerfano River. While here the chief rocks are sandstone and conglomerate, the neighboring hills are covered with *débris* and pebbles of granite, trachyte, and basalt-drifts from the mountains. About four miles west of Gardner's Store, a little settlement in the Huerfano Valley, are some very steep and barren peaks, the so-called Sheep Mountains. These have an elevation of 8,400 feet, and consist of a purplish rhyolite, exceedingly rich in silica, with large sanidin crystals sparingly embedded. The mountain-sides are covered with small sharp fragments of rock, evidently yielding, but very difficult to disintegrate. About half a mile south of Gardner's Store a steep trachyte butte, of about 160 feet in height, stands sentinel-like in the valley, and forms an abrupt contrast with the surrounding undulating surface. This trachyte is of a fine-grained gray matrix, in which numerous hornblende crystals are embedded. In most of the creeks of the Huerfano Valley gold has been discovered, but in very little quantity. The agricultural lands of the valley are valued at $17 an acre, on the ground that they are mineral lands. If the small quantity of gold referred to did not exist in this valley, these lands would, like the other agricultural lands hereabout, be valued at only $1.50 an acre. Formerly, some fifteen miles southwest of the Huerfano Park, in the vicinity of Placer Creek and east of Baldy Peak, a conspicuous, barren peak of the Sierra Blanca, good placers existed. These placers, called "Gray Back," have, according to a statement made to me, been worked with considerable success fifty years ago by Mexicans, and for a time by Kit Carson. At these placers we met three poor-looking individuals, who complained of the meager results of their labors; they had hardly cleared 25 cents a day from their gold-search. They considered the placers worked out and exhausted, and intended leaving at an early day. The gold is found in reddish clayey and siliceous deposits, rusty quartzites, and conglomerate, forming beds along the Placer Creek, which are bordered by gneissic and granitic hills. To the east and northeast of these hills paleozoic limestone occurs in great masses, with strata much tilted and displaced. The main rocks of the neighboring Cerro Blanco, the highest and most southern portion of the Sangre de Cristo Mountains, are

primitive rocks, intersected here and there by rhyolitic dikes. The top of the highest peak shows a vein of serpentine and of a porous ferruginous quartz, in which particles of malachite can readily be detected, and contains most likely a small proportion of gold. This quartz-vein is 6 inches thick. The peaks rise more than 2,000 feet above the timber-line, and, with the exception of a solitary specimen of a thistle or a graminee, are perfectly barren. The crests are rugged and sides steep; and the slopes being covered with sharp fragments of siliceous rocks, the ascent of these peaks is laborious and difficult.

Descending the southern slopes of the Cerro Blanco we reach the valley of the Ute Creek and Fort Garland, where the Carboniferous again becomes prominent, covering the rim of San Luis Valley to a great extent. The southern portion of this valley is covered by extensive sheets of basalt reaching from Culebra and the vicinity of Costilla as far west as the base of the San Juan Mountains. The Rio Grande and San Antonio Creek, (or Rito de los Pinos,) one of its tributaries, have cut deep channels through the volcanic material. The Ute Mountain and Mountain San Antonio are two isolated basalt cones rising from the volcanic sheets. The basalt from the vicinity of Culebra has a crystalline structure and is accompanied by dolerite, while at the Ute Mountain it is amygdaloid, and contains in these amygdaloid spaces reniform carbonate of lime.

THE SAN JUAN MOUNTAINS.

This important and extensive range of mountains was crossed by division No. 2, to which I was attached, in the most southern portion, and I had no opportunity to examine its more northern parts. The chief mass of these mountains is undoubtedly composed of rocks of Azoic age, but so frequently and extensively are they intersected by rhyolitic and trachytic dikes that the latter appears almost as the prevailing material. Sandstone and limestone of Paleozoic age skirt the foot-hills and spurs of the higher ridges. The granite of these mountains resembles that of the Cerro Blanco exactly in structure and in lithological character; the feldspar is white and forms a fine granular mixture with the particles of quartz, while the biotite is not uniformly distributed through the mass, but concentrates in larger masses, producing a spotted appearance. On the southern slopes of the mountains, in the vicinity of the Brazos Creek, quartzite becomes massive, and a cañon of 800 feet in depth has been cut in the rock by this river. This quartzite is joined toward the eastward by volcanic scoria and conglomerate, while just north of it rhyolite occurs. This rock is there of a uniform purplish matrix, containing sparingly embedded crystals of sanidine and hornblende.

Descending farther to the southward we pass through the Carboniferous strata into the extensive Eocene beds that have been so minutely examined by Professor Cope, paleontologist of the expedition. Near Abiquiu, forty-seven miles south of Tierra Amarilla, these beds present the same barren forms and grotesque architecture as the analogous deposits of the "*mauvaises terres*" of Dakota.

The extreme southeastern portions of the San Juan range give rise to the El Rito Creek and Caliente Creek, tributaries of the Chama, the latter flowing into the Rio Grande a little above Santa Clara. The Ojo Caliente Creek cuts its way through quartzite and trachyte, then through gneiss and granite, and finally through basalt and the Eocene beds. About fourteen miles above its junction with the Chama are the famous hot springs described in Vol. III of the Survey Reports. The gray, fine-grained gneiss in which these springs take their rise, is intersected in a direction northeast to southwest by a dike, from 3 to 8 feet wide, of granite, perhaps the coarsest ever observed; the reddish feldspar forms masses of 4 to 5 cubic feet, the quartz of from 1 to 6 cubic feet, and the muscovite large plates several inches in thickness.

About three miles south of the hot springs is a basaltic mesa, 160 feet high, which forces the river into a westerly course. A close examination of this mesa revealed the fact that its interior is sandstone, while the basaltic sheet on the top and the vast masses of basaltic bowlders covering the sides create the opinion on first sight that it is exclusively volcanic. Doubtless this mesa represents a sandstone island that resisted the erosive force under the protection of the basaltic cover, while the adjacent strata formerly in existence have been carried away by the waters. Cases quite analogous occur in the vicinity of Abiquiu. There the Carboniferous sandstone formed the shores of the Tertiary sea, and represents a very fine-grained, hard rock, made up entirely of particles of quartz cemented together by silicic acid. Hydrochloric acid has not the slightest action on this cementing material, showing that no carbonate of lime is present.

In connection with this sandstone, it should be mentioned that the surfaces for a considerable distance are covered with a black crust about $\frac{1}{16}$ of an inch thick, a peculiarity not often met with. This black crust is soluble in hydrochloric acid with disengagement of chlorine gas, and the solution thus formed gives all the specific tests for manganese. The black crust is therefore black oxide of manganese, and is probably the deposit of water that contained considerable quantities of carbonate of

manganese in solution, which latter was oxidized to peroxide with the loss of the carbonic acid.

The basalt of Abiquiu forms transitions into dolerite, and contains labradorite in well-formed, comparatively large, crystals of a fine blue iridescence and partially lamellar structure. Olivine occurs in large crystals. Basalt, however, also occurs there of such dense structure that no crystalline constituents are distinguishable with the naked eye. One specimen of such basalt, of ink-black luster, was subjected to analysis, and the following result obtained:

Silicic acid	45.39
Magnetic oxide of iron	19.02
Alumina	10.51
Lime	9.97
Magnesia	9.78
Potassa	2.01
Soda	1.43
Lithia	trace
Protoxide of manganese	trace
Oxide of nickel	trace
Oxide of cobalt	trace
Titanic acid	trace
Phosphoric acid	trace
Sulphuric acid	trace
	98.11

THE MOUNTAIN REGION OF ABIQUIU.

Under this head is comprised the extensive mountainous region between Abiquiu, in the north, Jemez, in the south, and Nacimiento, in the west—a region as unique in topographical and geological respects as it is full of charming features and picturesque grandeur. Before considering it in detail let us take a hasty bird's-eye view of the geological structure of this section.

The chief mass consists of trachyte and rhyolite, of which immense quantities have here been ejected from the interior of the earth, overflowing the Paleozoic strata which rest upon the granites. Colossal cañons have been washed into the trachytes and the underlying sandstones. In some instances, however, the erosion has been carried down to the granites, as in the upper portions of the Cañon Guadalupe. Strata of volcanic tufa, of great thickness, have been formed—a proof that this mountain region was partly submerged for some time after the volcanic forces had ceased. But Pluto was not only active here during the Tertiary epoch; much earlier, in the Paleozoic times, eruptive masses were thrown up. Red eruptive gneiss and granite appear in the Carboniferous strata; the former fifteen miles north of Jemez, in the Cañon de San Diego, the latter, six miles west of this town on a mountain. It is only the most western portions of this immense mountain region that is comparatively free from eruptive rocks.

In the most northern and eastern portions we observe, along the base of the mountain mass, basaltic protrusions from Abiquiu to the mouth of Bear Creek; from there to Ildefonso, and thence along the mountain base to Jemez. Near the mouth of Rio del Oso, an insignificant tributary of the Chama rising at the foot of Abiquiu Peak, the basalt contains white crystalline zeolitic masses, partially transformed by disintegration into carbonate of lime. Carefully-selected crystals, not covered with the incrustating carbonate of lime, were subjected to chemical examination. The air-dry powder sustained a loss of 4.01 per cent. at 100° C., but on ignition 16.51 per cent. more was lost. Hydrochloric acid produced a partial decomposition of the powdered crystals. A complete decomposition, however, was effected by fusion with carbonate of soda. Hydrofluoric acid also acts rapidly, and the solution obtained with it served for the determination of the alkalies. The following shows the chemical composition of this zeolite:

Silica	48.21
Alumina	19.75
Lime	10.43
Soda	0.98
Potassa	1.01
Water	20.58
Total	100.96

From zeolites, the carbonate of lime met with in basalts may often be derived. Chemistry forbids the assertion that carbonate of lime is an original constituent of certain basalts; still, the occurrence of carbonate of lime in the amygdaloid spaces of basalts is quite frequent in New Mexico.

As we leave the base of the mountains and ascend, basalt disappears, trachyte taking its place, with rhyolite, pumice, and obsidian as accompaniments. The pumice covers a great area some six miles west of Ildefonso, while the obsidian is met farther up, forming large, massive rocks, and assuming quite a porphyritic appearance by its inclosed radiating masses of zeolite, (spherulite.) Especially is this the case in the northern portions of the Valle Grande, a great mountain park near the Jemez Peak. The creek that runs through that portion was called by our party Obsidian Creek; it forms one of the head branches of the Jemez Creek. In some cases the obsidian is nearly colorless; generally, however, it is of the usual black, glassy appearance. Pebbles of obsidian are a conspicuous feature in some of the conglomerates and tufas in the vicinity of Cerro Pedernal, where the Rio Polvadera and Ojo de Cuerpospin unite to form the Rio de Canones, a tributary of the Chama. In this vicinity, as well as farther south in the valley of the Obsidian Creek, are evidences of the glacial epoch, prominent moraines extending far down into the valleys adjoining the peaks.

It is a remarkable feature of this plateau that almost every spring here has a higher temperature than is usually the case in such altitudes. Several large springs, full of trout, in the valley of Obsidian Creek have a temperature of 56° F., and this appears to be the temperature throughout the year. It was the same in June, 1873, when we passed these springs, as in September, 1874; and in the morning, with the air-temperature below the freezing-point, it was exactly the same as in the afternoon, when the thermometer showed 66°, which is evidence that the supply of water from beneath is so rapid that external changes of temperature do not apparently affect the temperature of the springs. Several miles west of this place, where the Obsidian Creek enters the cañon—the head of Cañon de San Diego—are four springs with a temperature of 84° F., the warm waters of which concentrate near by, forming a sort of swamp, in which many of the lower order of animals have an existence otherwise impossible in this cold region. Here a large neuropterous insect with red wings deposits its eggs, the larvæ growing up in the warm pool. Frogs, nowhere else to be seen in these moutains, abound here in great numbers. A plant, *Ceratophyllum demersum*, grows vigorously in this swamp.

Leaving this point and proceeding four miles down the cañon, our attention is arrested by a column of steam rising from among the pine trees on the bluffs. Ascending about 160 feet from the eastern margin of the stream, we meet with a large hot spring, called by our guide Spring San Antonio, the temperature of which is 105° F. The water is tasteless. The only mineral constituent it appears to contain is carbonate of lime, which forms thin crusts over the rocks with which the water comes in contact. Where the stream of hot water reaches the creek its temperature is 88°, while that of the water of the creek proper was 56°. (September 10. Air-temperature, 50° F.) After the mingling of the waters the temperature was 59° F. From these data it follows that the volume of the stream of hot water is 9.7 per cent. of that of the creek. A few miles below this locality the second head branch of the Jemez Creek comes in. This branch has numerous side cañons, among them one of great interest from its having a forest of columns resembling in figure but excelling in grandeur those of the Garden of the Gods, near Manitou, Colo. This locality we named Monument Cañon. These columns vary in thickness from 1 to 8 feet and in height from 10 to 50 feet, and are crowned with a large head of solid rock. The material of these columns is a conglomerate of trachytic pebbles and sand, washed from the adjacent declivities, whence came the blocks also which form the heads of the columns. The explanation of the formation of these columns is simple. Formerly the entire cañon was filled with sand, *débris*, and bowlders. The mass of sand beneath a large bowlder was, of course, subjected to a higher pressure than the neighboring strata, and hence the particles were better cemented than was the rest, and when afterward the erosive powers commenced their work, the softer parts succumbed while the cylindrical masses, with their bowlders as heads, resisted and remained.

Proceeding some fifteen miles farther south, in Cañon de San Diego, we reach the interesting Jemez hot springs, described in Vol. III of the Survey Reports. Near these springs the Carboniferous strata are well exposed, and *Spirifer cameratus*, *Productus striatus*, and *P. semireticulatus* are found in abundance. The red sandstone overlying the Carboniferous limestone contains here and there small deposits of copper-ore, chalcocite and malachite, with impressions of *Calamites*. Two miles south of the Jemez hot springs are the ruins of a smelting-furnace, but the scanty supply of copper-ore in the sandstone of course did not justify mining and metallurgical operations. From this point down to the junction of the two great cañons (Cañons de San Diego and Guadalupe, both from 800 to 1,400 feet deep,) are exposed in the sandstone sidewalls a great number of trachytic dikes, all in a vertical position, while in a number of places the sedimentary strata are much displaced and inclined.

Proceeding from the head of Cañon de San Diego to the westward, we cross the trachytic formation, and reach Rito Peñas Negras, a tributary of the Guadalupe, where the Carboniferous limestone is again seen. This rock contains, in this locality, oxide of iron, and all the shells found in it are more or less covered with a red layer of this substance. Going farther west, across ridges and valleys and through magnificent ine forests, we gradually lose sight of the volcanic rocks; but before leaving them we will take a glance at their lithological character.

Near the headwaters of the Bear Creek, in the vicinity of Abiquiu Peak, the gray feldspathic matrix of the trachytes is densely crowded with large needles of hornblende and crystals of sanidine, while, approaching the valley of the Rio Polvadera, labradorite, with a beautiful blue iridescence, becomes a conspicuous constituent, sanidine almost disappearing, and hornblende diminishing gradually until it entirely vanishes in the rocks of the Cañon de Santa Clara, south of Abiquiu Peak, the trachyte in this vicinity being full of spherulite. To the south of this cañon is a very siliceous rhyolite, devoid of any crystalline constituents, but colored red in spots by oxide of iron. Still farther south, near the valley of the Obsidian Creek, the trachyte becomes exceedingly rich in sanidine crystals of small size, hornblende being almost entirely absent. In more than one locality are unmistakable evidences of repeated trachytic outbursts, whereby the once-formed tufas have been brought to fusion. Not far south of Abiquiu I encountered a rhyolite with a reddish matrix, in which fragments of a gray rhyolite are embedded. This rock I consider a tufaceous deposit, which was subsequently subjected to an incomplete fusion by the heat of the neighboring trachytic protrusions. All along the upper portions of Guadalupe River the granite and gneiss become uncovered by the Carboniferous strata. The granite is of a dense structure, and the feldspar of a reddish color. The mica is the black variety, or biotite, while the quartz particles are of a subtranslucent character, as seen in certain jaspers and milky opals. On one side of the Guadalupe Valley we noticed a singular land-slide, which probably occurred quite recently: a tract of land of about 10,000 cubic feet had moved to the bottom of the valley, a distance of 50 or 60 yards.

Leaving the Guadalupe we have to cross another range, the Nacimiento, before reaching the Mexican village of Nacimiento. This range forms the northeastern boundary-line of a wide sandy terrace and mesa country, which I have termed the "Nacimiento Desert."

THE NACIMIENTO DESERT.

This barren waste comprises all the land between the Rio Puerco in the east to Fort Defiance or Cañon Bonito in the west, and from Mount Taylor in the south to Nacimiento and Ojo San José in the north, covering more than five thousand square miles, and having an average elevation of about 5,900 feet above sea-level. The vegetation is exceedingly poor, with the exception of a few localities that possess a higher elevation than the average. One of these forest islands amid this sand-waste is formed by a very high mesa north of Bacon Springs and northeast of Fort Wingate. The topographic features of this desert consist in a continuous system of mesas and valleys hardly equaled anywhere on the globe. The trapezoidic forms of mesas, ranging in height from 50 to 300 feet, stretch many miles in monotonous uniformity. In the eastern section are the Mesas de los Portales, de la Ventana, de los Torreones, and de la Piedra Lumbre; in the northern the Mesas de los Lobos and del Raton; in the southern, Mesas de Joro, Pintada, and Rotonda; and in the western section Mesas Trastchi-Tchibito, and Tistsitloe, (Navajo names.) Once upon the mesas it is difficult to find a place to descend, and only by chance is a narrow trail found that leads to the valley; in any event the descent is a dangerous undertaking.

Some forty miles to the west of Nacimiento one of the larger mesas forms the divide between the Atlantic and Pacific, here hardly marked by an elevation, while usually high mountain ranges represent the dividing-line between these oceans. The Rio Puerco of the east, and its tributary, the Rito Torreones, flow through the mesa system to the eastward into the Rio Grande, while the Chaco Creek, the head of which is forty-two miles west of Nacimiento, forms a tributary of the Rio San Juan. These once powerful streams are now scarcely more than dry arroyos. The question arises, how was this extensive mesa system produced? Of course by erosion; but how was the erosion brought about? Erosion can be active in the form of rain, rivers, submarine currents; but none of these agents were at work here. The most probable theory is in the wearing action of the tidal motions of the slowly-receding waves which began when the retreating Cretaceous ocean had as its shores the same deposits that were formed before at the bottom of its depths. This view is confirmed by the existence of many very deep and at the same time very short cañons in these mesas representing former bays of the receding Cretaceous ocean—cañons whose character forbids the idea that they are the result of erosion by supposed rivers. In a similar manner, according to my belief, were the great mesas of the Moqui country in Eastern Arizona formed.

The chief formation throughout the Nacimiento Desert is the Cretaceous; the older formations, like the Triassic and Carboniferous, being exposed in only a few localities

the Triassic northeast of Bacon Springs, and the Carboniferous near Fort Wingate, in a natural, undisturbed position. But in the Nacimiento range it is different, the Carboniferous strata occupying the very crest of the mountains several thousand feet above the Cretaceous formation, leaving no room to doubt that this range is the product of an upheaving which occurred toward the close of the Carboniferous epoch. A section of this region is presented in Fig. 2.

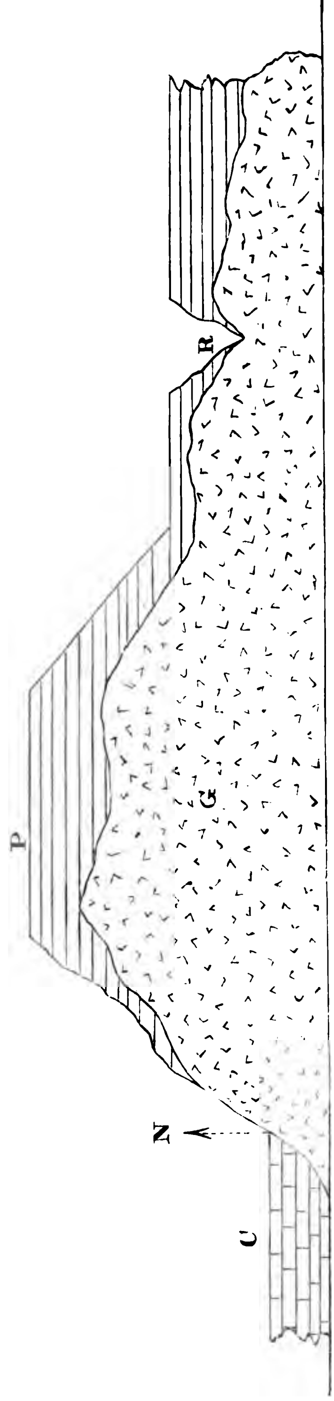


FIG. 2.—Section showing the relative position of the Carboniferous strata (P) on the Granite Mounta.. n, (G,) and the Cretaceous (C,) near Nacimiento (N;) R, Guadalupe River.

The predominating rock of the Cretaceous mesas of Nacimiento Desert is sandstone, while limestone, of such frequent occurrence in the Cretaceous deposits of the Arkansas Valley, is here remarkably rare. Slate, clays, and brown coal form here and there subordinate strata of the sandstone. In the slate are found impressions of leaves as well as an occasional *Inoceramus*. The brown coal contains a yellow brittle resin, which on examination proved to be new to science, and was described in vol. III of the Survey Reports, under the name "Wheelerite." Fibrous gypsum of silky luster accompanies the brown coal; also limonite occasionally.

In a number of mesas along the Rito Torreones, the brown-coal strata have been destroyed by fire, at least the exterior portion of the seams, the ashes still being there. The overlying clay strata were entirely metamorphosed by the heat and turned into brick, having a blood-red color, and giving out a ringing sound. The underlying ferruginous and calcareous shales were turned into a vesicular slag. I observed a similar state of things in analogous strata in the Moqui country.

In regard to the succession of the strata, I took quite a number of sections. At the Rio Puerco the following order appeared:

	Feet.
Top light-colored sandstone	4
Slate clay	0.5
Brown sandstone	0.75
Slate	0.30
Brown coal	2
Base slate	6.2

In one mesa bording the Rito Torreones the strata were exposed in the following order of succession:

	Feet.
Top yellow sandstone	20
Brown coal	0.5
Slate	4.75
Brown sandstone	5

Gypsum deposits of considerable thickness occur east of the Rio Puerco in several places. Between Ojo del Espiritu Santo and the Rio Puerco the mesas show a dip of 20° to 25°, while the strata elsewhere show no disturbance or displacement from a horizontal position. Here and there we meet with granite hills in the northeastern portion of the Nacimiento Desert, forming a striking contrast to the surrounding mesas. These hills were formerly cliffs in the Cretaceous ocean.

Proceeding from the Rito Torreones toward Mount Taylor, we pass a valley surrounded by most picturesque sandstone forms, resembling castles, towers, and monuments, all the result of erosive agencies. A little farther south the vol-

canic activity has produced a change in the mesa scenery, the basaltic Cerro de Cabezon resembling a gigantic *sombrero*, and the Cerro de Alesna an imposing pyramid, forming a striking contrast with the trapezoid mesas in the vicinity. Basaltic protrusions in the Cretaceous formation of the Nacimiento Desert also occur farther west, toward Fort Defiance. The sandstone of the mesas is chiefly calcareous, and occurs occasionally in plates of 2 to 6 inches thick, separated from one another by a thin crust of carbonate of lime. The sandstone plates were used by the former Indian inhabitants as building material for houses and fortifications, of which a great number are found on the Cañon de Chaco. A specimen of this sandstone was treated with hydrochloric acid, by which a complete conversion to the granules composing the rock was effected, the cementing material, carbonate of lime, being dissolved. These granules consist chiefly of quartz, but feldspar, mica, and hornblende particles are readily discovered among them. The composition of the sandstone is as follows:

Granules		59.25
Clay		2.23
Soluble in hydrochloric acid.	Carbonate of lime	34.70
	Carbonate of magnesia	2.43
	Oxide of iron	1.51
		100.12

The amount of cementing material is here unusually large.

An interesting fact is the occurrence of fine blood-red garnets in the western portions of the Nacimiento Desert. Over large areas, some ten or fifteen miles east of Fort Defiance, we find these beautiful gems scattered in the loose sand. Their exterior surfaces are much worn, indicating, apparently, transportation from a great distance. Indeed, there is no rock in the neighborhood that might have originally contained them; but some fifty miles to the northward is a syenite, which contains large masses of garnets; there may, however, formerly have been garnetiferous syenite, or schists, in existence much nearer than this. It is worthy of mention that among the pebbles composing the ant-hills, it is usual to find the finest colors of garnets, which leads to the supposition that bright colors have a peculiar attraction for these ants. The finding of garnets in this region gave the first impulse to the memorable diamond-excitement of some years ago; and although that gigantic swindle is a thing of the past, these objects still bear the name "ruby-spinel." Their hardness is 7, and specific gravity 3.75; while the average absolute weight is about one gram, and diameter $\frac{1}{12}$ to $\frac{1}{8}$ of an inch. On being analyzed the following was shown to be their composition:

	I.	II.
Silicic acid	45.80	41.35
Protoxide of manganese	trace.	2.59
Lime	6.43	5.29
Magnesia	16.60	15.00
Perotoxide of iron	10.96	9.94
Proxide of iron	2.00	......
Alumina	19.25	22.35
Chromic oxide	trace.	4.17
Total	101.04	100.69

For comparison the composition is given under II of a pyrope-garnet from Bohemia, analyzed by Moberg, which shows that the blood-red garnets of Fort Defiance belong to this variety. There are, in fact, quite a number of varieties of garnets which differ widely in composition, but having a crystalline form closely agreeing with each other. The noble garnet, or almandine, is an alumina-iron garnet; the pyrope, an alumina-magnesia garnet; the grossularite, an alumina-lime garnet; besides these there are chrome garnets, lime chrome, lime-magnesia iron, and manganese-alumina garnets. They often occur of green, red, and violet color; also colorless and black.

Together with the blood-red garnets of Fort Defiance are found green transparent granules worn off like the former, so that their crystal faces cannot be recognized. At first I took them for green garnets; subsequent examination, however, proved that I was in error. Their specific gravity is 3.20; hardness, 6; and their chemical composition corresponds to that of the chrysolite, as follows:

	I.	II.
Silicic acid	43.02	43.44
Magnesia	48.15	49.31
Ferrous oxide	7.42	6.93
Alumina	trace.	trace.
Lime	trace.	trace.
Oxide of nickel	0.21	0.32
Oxide of cobalt	trace.	trace.
	98.80	100.00

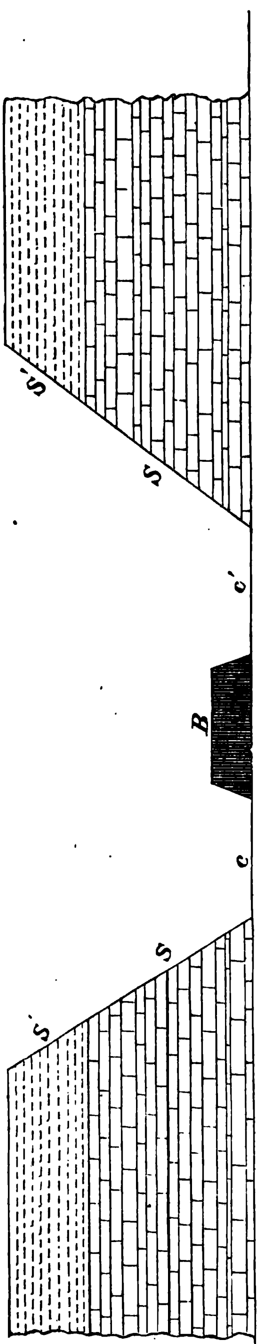


FIG. 3.—Section of the bed of the Rio San José two miles east of Laguna, showing the basaltic flow (B) in the middle of the river-bed, (c c'.) S' = white sandstone; S = red sandstone; c = present river-bed.

For comparison the analysis of a chrysolite coming nearest to the green garnet in composition, is given in No. II. It was selected from a number of analyses made of chrysolite from different localities, and mentioned in Dana's Descriptive Mineralogy. This chrysolite (No. II) came from Hecla, in Iceland, and was analyzed by Dr. A. Genth. It is a remarkable fact that all the chrysolites analyzed since Strohmeyer have been shown to contain nickel and, most of them, also a trace of cobalt. Chrysolite also forms, as is well known, a constituent of certain meteoric stones and of basalts. Genth maintains that chrysolite is the source from which talc, slate, and many of the serpentines have been formed, and sustains this assertion by substantial arguments. He says: "In the change of chrysolite into talc and serpentine a portion of the magnesia is eliminated, which separates either as brucite, hydromagnesite, magnesite or dolomite, minerals which occur more or less at the principal serpentine localities."

FROM MOUNT TAYLOR TO THE PLACER MOUNTAINS.

Mount Taylor, next to Baldy, of the Santa Fé range—the highest peak in New Mexico—represents an isolated and ancient colossal volcano which towers above large portions of the country and is visible for great distances. It has given birth to volcanic floods of gigantic dimensions, flooding the adjacent valleys, displacing rivers from their beds, and filling them with quite an unusually hot liquid. One stream of liquid basalt followed the bed of the Rio San José for some distance but did not fill it, so that the water of this river still runs in its original course, having, however, now on one of its sides a basaltic mass instead of a sandstone wall, as represented in Fig. 3.

While the basalt occupies the lower portions of Mount Taylor and is spread along its base, the top of the mountain shows a different volcanic product, namely, *trachyte*. It has a reddish-violet matrix, and contains large crystals of sanidine. While this rock is here of great uniformity, the basalt occurs in a number of varieties, containing alternately olivine, leucite, and nepheline—rarely zeolite, although this latter variety is not infrequently met with in New Mexico, among other places at Cuchilla, on the Rio de Chama, and the cañon of the Santa Fé Creek, a mile below Cieneguilla. The classification used by Dr. E. Boviky for the basalts of Bohemia may be applied also to those of New Mexico. He distinguishes six varieties: (1) magma basalt; (2) nepheline basalt; (3) leucit basalt; (4) feldspar basalt; (5) trachy basalt; and (6) tacily basalt. (American Journal of Science, 1873.)

It is a noticeable coincidence that in the San Juan range, Abiquiu Mountains, and Mount Taylor the basalt occupies the bases and lower terraces of the mountains and ranges, while rhyolite and trachyte occupy the higher portions and the tops of the peaks. There can be only one explanation for this regularity, which is, that basalt fuses at a lower temperature, has a less viscous fluidity, and takes longer to solidify, and therefore flows off in sheets, while the trachyte and rhyolite solidify quickly whenever they are ejected, and consequently compose the crest of the mountains. The more silica a rock contains the more difficult is it to fuse it, as a rule. But not only does the difference in the relative position of these volcanic rocks strike our attention, but also their very frequent association and co-occurrence. In New Mexico we find the basalts and trachytes so intimately connected with each other that the supposition is suggested that they came up through the same fissures of the earth's crust, and perhaps in some cases were thrown up together. This possibility is easy of com-

prehension, if we consider that the liquid interior of the earth is most probably composed of concentric layers of different materials placed in the order of their specific gravities. Beneath the granite we find the molten trachytes, and beneath these the basalts, the latter forming the ferruginous slags of the iron center of the earth. The existence of the latter can be inferred not only from the calculated specific gravity for the interior of the earth, (8,) but also from the earth's magnetism. This iron is, in all probability, identical with the meteoric iron; *i. e.*, it contains nickel and cobalt, judging from the presence of these elements in basalts, which I have demonstrated in a former report. (Vol. III. Survey Reports.)

Taking the trail from San Mateo, a Mexican village on the northern foot of Mount Taylor, to Laguna, situated southeast of this mountain, we find ourselves, on emerging from the forest, upon a high, perpendicular bluff, where a grand panorama meets the view. Before us is a wide, level country, bordered in the east by the Sierra Zandia, and in the south by the Ladrone, Madalena range, and Sierra Mimbres. The sheet of basalt on which we stand is fully 30 feet thick, and rests upon a sandstone stratum exposed to a height of 700 feet.

Leaving Chaporero, a small Mexican settlement on the base of this bluff, we descend, a short way off, another bluff, or wall, of sandstone, 300 feet in height, and reach Povate, an Indian town. A few miles south we pass another terrace, 200 feet in height, and soon afterward one at Laguna. Sixteen miles south of west from this Pueblo is another Indian village, Acoma, on a sandstone mesa 200 feet high. No basalt is seen in this vicinity, but it covers large areas to the north and northwest. The country between Laguna and Acoma is a barren, sandy waste, upon which huge masses of sandstone and mesas rest, and which is partially covered by juniper woods.

The sedimentary strata at Laguna are all of Cretaceous age. The lower strata consist of red sandstones and marls, the upper of yellow calcareous sandstones with seams of shale. Taking from Sheep Spring, five miles east of Laguna, a straight northeasterly course we reach San Ignacio, on the banks of the Rio Puerco, after a journey of thirty miles. This stretch is covered the entire way by the deposits of the Cretaceous period, sandstone being the predominating mass, followed by marls and clays, then gypsum and brown coal. Pebbles of flint and jasper occur in great numbers, but fossils are unusually rare. Here and there are ammonites or an *Inoceramus*. Here is the southern continuation of the great mesa system of the Nacimiento desert. Some eight miles above the town of San Ignacio the Rio Puerco emerges from a cañon, but near this town the valley is very broad and evidently is the result solely of erosion. The Cretaceous formation does not cease here, but extends without interruption eastward to the Rio Grande and Jemez Creek. The mesas, however, disappear gradually, their places being taken by an undulating country covered thickly with loose, heavy sand.

At Santa Ana, an Indian town on the Jemez Creek, we again encounter the basalt, which here also covers immense tracts of land on both sides of the Rio Grande. It extends westward from Santa Ana, northward as far as Jemez and on the east side of the Rio Grande from La Bajada to San Ildefonso. This immense sheet of basalt is bordered on the east side by the *Cerillòs*, a chain of hills principally of volcanic origin, where we again find basalt and trachyte associated. These hills are some seventeen miles southwest of Santa Fé, and not only has silver been discovered in them in several places, but also a rare gem—turquoise. One of these hills, not far from the bed of the Galisteo, and consisting of a light purplish trachyte with small crystals of sanidine and hornblende, is traversed by numerous seams of green and blue turquoise from $\frac{1}{8}$ to $\frac{1}{6}$ of an inch thick. The fine sky, blue color, however, is rarely found with these turquoises, and all the larger seams exhibit a dirty green coloration. How this gem was deposited in the fissures of the trachyte is a mystery. It certainly was not an original constituent of this rock, as may be inferred from its containing water of hydration. In the few other localities where turquoise was found it occurs in clay-slate or quartzoze schist, and forms also narrow seams. The finest turquoise is found in Persia in the neighborhood of Nichabaur; other localities where it occurs are in Arabia, Asia Minor, and Silesia.

As thus far turquoise had been but rarely investigated, I deemed it of interest to determine the composition of that of the Los Cerillos. The fact was thus revealed that it contained over 12 per cent. of silicic acid, a substance not found before in this gem, and as I was very careful in the separation of the seams of turquoise from the trachyte, this cannot be attributed to an admixture of trachyte particles. In the following table is given the analytical result (I); also (under II) the composition of Persian turquoise, as ascertained by Church :

	I.	II.
Phosphoric acid	29.57	32.86
Alumina	29.17	40.19
Water	18.85	19.34
Oxide of copper	4.04	5.27
Protoxide of iron	4.35	2.21
Lime	1.61	......
Silicic acid	12.57	......
Protoxide of manganese	......	0.36
	100.16	100.23

Large excavations in the turquoise-bearing hill of Los Cerillos tend to testify that this gem was eagerly sought after years ago. The Spaniards, on entering Mexico, found ornamental jewelry made from this gem in many Indian towns. For a long time, however, it was a mystery to them in which locality this gem, called by the Mexicans, to this day, "chalchihuitl," was found; said locality is the Cerillos. As an instance of the spread of this gem by the Indians, it may be mentioned that Mr. Lockwood, of this survey, found a small, perforated, polished plate of it amid broken pottery, on a peak, 11,000 feet in height, of the Sierra Blanca, in Arizona.

From Los Cerillos we proceeded toward the neighboring Placer Mountains, encountering in the numerous cañons seams of coal, corresponding, in chemical composition, to anthracite; to this attention is called in vol. III of the Survey Reports. Farther up along the base of the Placer Mountains, carboniferous limestone is met with skirting the foot of the masses of Azoic rocks which compose the Placer Mountains. The Zandia Mountains bordering these in the southwest represent quite analogous features. With regard to mines it may be stated that, while the former contain important gold-mines, the latter have good copper-ore. Between the Placer Mountains and Santa Fé we cross several valleys of erosion, in which the Triassic beds with their characteristic fossil-wood are well exposed. At Santa Fé, however, near the base of the mountains, is again found the Carboniferous limestone.

With regard to the Rio Grande Valley, may be mentioned the existence of Tertiary fresh-water deposits near Algodones; also, numerous exposures of brown coal, especially farther south. There is one 3 feet thick near Doña Ana and Mesilla, another at Robledo, near La Joya, north of Fort Craig, and one at San Félipe. Other coal-beds exist in the range Madalena, in Tijeras Cañon, five miles east of Algodones, west of Las Lunas, in the valley of the Rio Puerco, four miles above Anton Chico, and in the valley of the Rabbit-ear Creek.

A fact of some interest is, that almost all the tributaries of the Rio Grande carry turbid waters, which become exceedingly muddy after rains. The quantity of material transported by this stream down to the gulf is immense. Chama, Jemez, and Puerco rivers deserve special mention. Thus are agencies here energetically at work to destroy the older formations and build up new ones at the bottom of the Gulf of Mexico.

THE MOUNTAINS BETWEEN SANTA FÉ AND LAS VEGAS.

That portion of the Rocky Mountain range which separates the cities of Santa Fé and Las Vegas extends but little farther south, and terminates near the valley of the Galisteo. Once more this mighty range rises to gigantic proportions before dying out in the plain. Unlike other portions of this range, and unlike most other mountain systems in New Mexico, this mighty elevation between Santa Fé and Las Vegas is free from more recent eruptive rocks; basalt, trachyte, and rhyolite being absent. Nevertheless, these mountains were not in a state of repose in older epochs, as shown by the upheaved sedimentary ridges along the western and southern base, and the red granite thrown up during the Carboniferous epoch. Taking a bird's-eye view of this region, we see the old Azoic rocks occupying the larger part of this area. Of sedimentary rocks, none more recent than the Carboniferous are visible, and these are principally in the valleys of the streams; but, proceeding into lower regions toward the base of the mountains, we come gradually to the Triassic and Cretaceous (probably, also, Jurassic) strata.

The whole mountain mass between Santa Fé and Las Vegas is divided into two branches, or arms, by the Pecos River, the western forming the Santa Fé range, the eastern the Gallinas Mountains, the Gallinas Creek here taking its rise. Both these branches form a series of steep ridges, elongated spurs, rocky slopes, and deeply excavated valleys. The most prominent peak of the western range is Baldy Peak, with an average elevation of 12,400 feet above sea-level, whose summit is often covered with snow in midsummer. A great number of streams take their rise in these mountains, the Santa Clara, (or Rio de Cañada,) Pojoaque, Tesuque, and Santa Fé Creek flowing to the west and southwest, the Pecos and its tributaries, Macho, Vaca, and Tecolote toward the south, and the Gallinas toward the east, at least until it leaves the foot-hills of the mountains. The mountains are partially well-timbered, partially covered with fallen timber, and partially barren.

Local geology.—Proceeding from the Rio Grande at Santa Clara toward Baldy Peak, we first cross the soft Tertiary beds, sands, clays, and marls, forming a nearly perfectly barren stretch, especially between Pajoaque and San Juan, and yielding much to erosive influences, whereby many narrow gulleys, and here and there peculiar architectural forms, are produced. In these beds, near Ildefonso, I made some excavations in 1873, while on the way to Fort Defiance under your expedition, (division 2,) and brought to light fossil bones of a mastodon, only one of them perfect, however; others were broken and yielded but fragments. Unfortunately I had but one day for this work, but in 1874 Professor Cope made more extensive excavations while attached to this expedition. He succeeded in discovering many precious treasures in the line of Tertiary fauna. Only one spot appeared to promise results. I searched in vain all the way from Pojoaque to San Juan in the fall of 1874, when passing again through this region. Leaving these beds, and proceeding eastwardly toward the mountains, we crossed, before reaching their base, a bed of rounded pebbles and detritus of the Azoic rocks of the mountains. About five miles above the Indian town Nambé, the Rito Pojoaque emerges from a deep, narrow valley in which the Carboniferous strata are exposed, but for only a comparatively short distance, the Azoic rocks, principally granite, predominating here as well as in the cañon of the neighboring Rio Tesuque and Santa Fé Creek.

The Rito Tesuque is formed by three head-streams that unite far up in the mountains, about fifteen miles above the Indian town Tesuque. These head-streams are all hemmed in by narrow, well-timbered valleys, that turn, with larger or smaller interruptions, into cañons. One and a half miles below the junction of the first two of these streams, which occurs in a charming little mountain valley, the Vallecito, comes in the third branch from a narrow gorge in the granite rocks, and about two miles below this junction two other side cañons come in, but at the present day no water flows in them. The granite in the northern of these side cañons is of a very coarse texture and has the white mica (muscovite) as a constituent. In the numerous fissures of this rock is a coating of shining oxide of iron, producing an appearance seldom seen. It may have been deposited by the waters of a former iron spring. It is a fact that some prospectors in Santa Fé took this red substance for cinnabar, and the silvery-looking particles of muscovite for mercury. Several miles farther down the river is the Carboniferous limestone with an abundance of *Productus* and *Spirifer*. These beds rest directly and conformably on the Azoic rocks. Between the Rito Tesuque and the Santa Fé Creek is a series of high and steep ridges composed chiefly of granite.

Where the Santa Fé Creek emerges from the foot-hills of the mountains stands the city of Santa Fé. The chief rocks north of this locality are the Azoic—gneiss and granite—while Carboniferous limestone is found in some of the neighboring cañons, and toward the south more recent formations up to the Cretaceous. Along the road from Santa Fé to Las Vegas is passed, first, gneiss, then a conglomerate, and afterward Carboniferous and Triassic beds near the Pecos River, next upturned sedimentary rocks for a long distance until we reach the level beds of the Cretaceous at Las Vegas. This road, however, describes large curves. The direct trail is much shorter, but leads across so many steep slopes that vehicles cannot make use of it. This trail leads up the Santa Fé Creek about ten miles, ascends a steep, barren declivity, some 2,000 feet in height, and crosses another deep valley before it reaches the Macho Creek, a tributary of the Pecos; thence it leads up the Pecos some distance and over another steep declivity to the valley of the Vaca Creek and to the headwaters of the Gallinas Creek.

In the valley of the Santa Fé Creek the gneiss is accompanied by primitive clay-slate and syenite. Veins of fine-grained gray gneiss occur in a coarse aplite or granulite, also intersected by syenite seams. These singular features are nicely exposed in the rocks bordering the river some five miles above Santa Fé. Farther up, some curiously-shaped huge rocks are seen projecting from the sides of the cañon; one of these is called "Bear rock," from its shape, resembling that of a bear.

In the cañon of the Macho Creek we again meet the Carboniferous limestone, which is in sight until we reach the junction with the Pecos, and from there to the top of the next ridge, on the eastern side of the Pecos Valley. Here the lithological character of the underlying granite is quite different from that west of the Macho Creek. It forms a fine-grained mixture of white feldspar and quartz, in which little spot-like aggregations of biotite are segregated. In the valley of the Vaca Creek, immediately east of that ridge, talcose schist and syenite are exposed, upon which the Carboniferous strata rest. Taking thence a northeasterly course to the headwaters of the Gallinas and Tecolote, we have to ascend another high, steep ridge, whose summit is fully 11,000 feet, and whose very top is covered with Carboniferous limestone. This fact, contrasted with the entire absence of such strata on the ridges and higher portions of the range west of the Pecos, appears to indicate that it was lifted after the deposition of these strata from the sea to this great height, while the Santa Fé range was in existence long before. This lifting to the present height, however, was not accomplished by one effort. Another exertion was made during the Cretaceous, as the belt of upturned Triassic and Cretaceous strata along the southeastern foot-hills of the range seems to testify, while no upturned ridges are observed on the western side of the Santa Fé range.

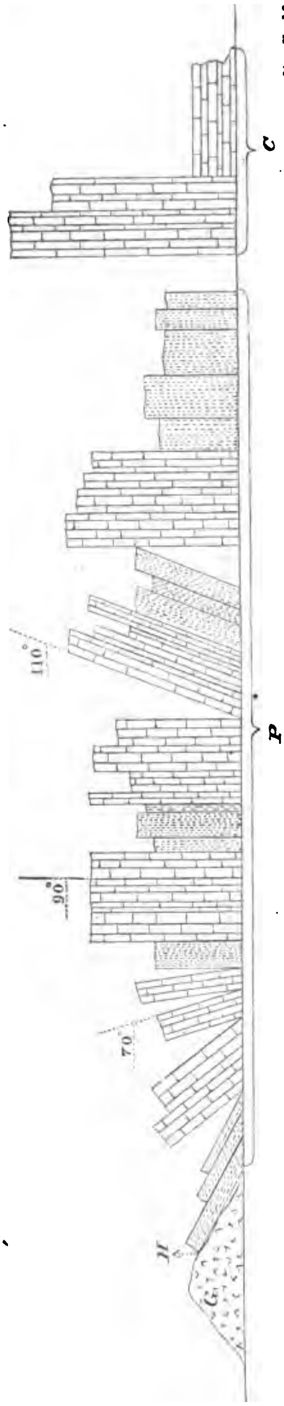


FIG. 4.—Section showing the upheaved strata in the Gallinas Valley, near the Las Vegas hot springs: G, red gneiss; H, hot springs; P, Paleozoic strata, extending half a mile and from 30 to 50 feet in height; C, Cretaceous strata.

Looking from the Gallinas Mountains to the eastward a singular view meets the eye. The mountains do not taper off gradually toward the plain, but, where the spurs have fallen off to about one-third the mountain's height, a high ridge, steep in the extreme, but of short extent, cutting the spurs of the Gallinas Mountains at right angles and forming a system of its own, stands prominently forth. The Gallinas River has cut a stupendous cañon through these masses, which is nearly 2,500 feet deep. While syenite composes the principal mass of the Gallinas Mountains, this strange elevation consists of fine-grained granite containing red and white feldspar and quartz, but relatively little biotite. This rock also exhibits transitions into gneiss and granulite. There can be but little doubt as regards the eruptive character of this granite. The nearly perpendicular faces of this huge granite mass constitute it a landmark prominently visible far out on the plain. From the north side the portion lying north of Gallinas Creek, called the Tecolote rock, may be easily climbed.

Leaving the Cañon of the Gallinas, we enter a moderately wide valley, and, following it, after a journey of eight miles, reach the hot springs of Las Vegas. Some two miles above this place, however, the river passes another narrow cañon about a mile long. At the hot springs we again encounter the Carboniferous, characterized here by the shells *Productus* and *Spirifer*. Le Conte, usually a good observer, has overlooked their existence when examining these regions as geologist of the Pacific Railroad survey. He remarks, "No Paleozoic rocks are seen between the dark-red sandstones and the gneissoid rock, the *Carboniferous limestone* being *here* absent." I observed the Carboniferous limestone resting directly on the red gneiss, from whose fissures hot waters issue. The rock is somewhat metamorphosed in contact with the gneiss, which latter is undoubtedly eruptive, as indicated by the bends and displacement of the limestone. The space left by the partially imperfect contact of the limestone with the gneiss is filled with a thin stratum of clay, from which efflorescences of alum develop. This is due to the percolating mineral-water, which contains, besides sulphate, carbonate, and chloride of sodium, a trace of sulphureted hydrogen—a trace so small, however, that it is hardly perceptible by the odor; still, it gives rise to the formation of sulphuric acid by undergoing oxidation, and, as the next consequence, the formation of alum and gypsum when this acid comes in contact with clay or limestone.

Passing from the hot springs eastwardly along the river there is a fine exhibition of the sedimentary strata, all, nearly, in a vertical position, extending about half a mile, and terminating upon entering the plains three miles north of Las Vegas. The Carboniferous limestone is followed by alternate layers of slate and shale, then (3) gray sandstone, (4) red, fine-grained sandstone, (5) limestone, (6) gray sandstone several hundred feet thick and widely projecting, and thus turning the river at right angles for some 50 feet; this rock shows beside the normal stratification a second and false one; (7) slate, (8) sandstone, (9) shales, (10) sandstone.

East of No. 10 all the strata have a horizontal position, and are of Cretaceous age, the predominating fossil being *Inoceramus problematicus*. The scarcity of the other fossils is in strange contrast with the abundance of this species. Should there be a certain connection between the nature of the limestone and the specific kind of shells contained in it? This limestone is an argillaceous one.

In the vicinity of Las Vegas a number of channels have been worn into the Cretaceous strata by tributaries of the Gallinas, and thus the succession of strata can be well studied. Limestone predominates; then follow slate, sandstone, clay, and lignite.

Of rare occurrence, not only here but also in the Cretaceous beds of America generally, is chalk—a mineral whose existence in this country was entirely unknown until quite recently. The bed of chalk three miles northeast of Las Vegas, in the vicinity of Green's ranch, is 2 feet thick. The material is very soft, of great whiteness, and is used by the Mexicans for whitewashing. It can be used directly for writing, like the English chalk. On treatment with hydrochloric acid but little remains insoluble, and this consists of clay. The solution obtained contains, besides lime, small quantities of alumina and magnesia. Although in general physical properties and in chemical composition this chalk cannot be distinguished from the English chalk, the miscroscope reveals a great difference. While the latter is largely made up of the microscopic shells of rhyzopods, no trace of organized forms can be discovered in the Las Vegas chalk. It is, therefore, an open question how this chalk was formed.

About a mile east of Green's ranch I noticed a singular phenomenon. The limestone here occurs in rhombic prisms, fitting on each other with regularity and exhibiting a most peculiar-jointed structure, resembling more an artificially paved road than a natural occurrence. I do not myself entertain the belief that this natural regularity is due to a tendency to crystallization, any more than is the formation of six-sided columns of basalt. The primitive blocks have a thickness of half a foot on an average, and can be used directly for building purposes like bricks.

The Las Vegas limestone frequently contains particles of iron pyrites, and in places is very bituminous, exhaling a strong odor of coal-oil, and leaving, on treatment with hydrochloric acid, a black residue consisting of a mixture of carbon particles and clay. Dolomitic limestone appears to be absent, and while crystalline structure is rather the exception, the rock has generally a slaty color and grain. It contains from 10 to 30 per cent. of clay, and thus forms hydraulic limestone. Half a mile east of Green's ranch is a stratum of excellent cement, as will be seen from the analysis of a sample:

Carbonate of lime	69.98
Carbonate of magnesia	Trace.
Clay	28.09
Moisture with trace of bitumen	1.22
	99.29

In the best cements the amount of clay is, on an average, 28 to 34 per cent., and I believe there are few localities where this proportion is encountered; hence, this cement may be of great value, at some future time, as an article of exportation. The cement of the commerce of the present is generally an artificial mixture, which, of course, cannot be as cheap as the natural product. Gypsum and alum occur some ten miles southeast of Las Vegas, but I did not have an opportunity to visit the locality.

Although not properly belonging to this chapter, I may here give the analysis of a green feldspar which occurs in some parts of the Rocky Mountains, and especially in the valley of Bear Creek, near Pike's Peak, where it is found in large well-formed crystals. Green feldspar is of very rare occurrence, not more than three or four localities where it exists being known. It was a question of interest to myself to what the green coloration is due. I had suspected the presence of copper, but the investigation showed that the color is due solely to the presence of a small amount of the protoxide of iron. In the following table the result of the analysis is given, (I,) and for comparison the composition of a green feldspar from Bodenmais, Bavaria, (II:)

	I.	II.
Silicic acid	67.01	63.12
Alumina	19.94	19.78
Protoxide of iron	0.89	1.51
Soda	3.15	2.11
Potassa	8.84	12.57
Lime	Trace.	0.66
Magnesia	Trace.	0.13
	99.83	99.88

The crystals of the green feldspar from Bear Creek are frequently over an inch in thickness, and contain minute cracks and fissures partially filled with hydrated oxide of iron, showing a partial alteration of the mineral.

CLIMATOLOGICAL NOTES.

During our stay in the extensive mountain region between Abiquiu, Nacimiento, and Jemez, in Northern New Mexico, I made hourly observations of the barometer and

psychrometer during five days. The sky was continuously clear during this period; wind weak, and chiefly from the west-southwest. The observations of the five days (September 4, 5, 7, 11, and 12) agreed so nearly with each other that I felt justified in taking these as the normal conditions for the season in this altitude. While I made observations in camp in the valleys, Mr. Hance observed on different occasions on the peaks near by. Usually, in meteorological reports, the *relative* humidity alone is calculated, the *absolute* being omitted, which, however, ought to be taken into consideration when comparisons of different climates are made. Both are given in the table which follows. The absolute, low as the figure appears, would in some of the observatons have to be expressed by half this quantity but for Regnault's correction for altitude.

Place.	Day.	Time.	Thermometer.		Barometer.	Humidity.	
			Dry.	Wet.		Absolute.	Relative.
			°	°			
Valley near Jemez Peak...	Sept. 10.	Sunrise...	24 F.	24 F.	21.960	3.6	100
Do....................	Sept. 10.	8 a. m....	35	32	22.016	4.3	71
Do....................	Sept. 10	9 a. m....	48	42.5	22.024	5.9	66
Do....................	Sept. 10.	10 a. m....	57	43.8	22.030	4.4	36
Do....................	Sept. 10.	11 a. m....	61	45.5	22.032	4.2	30
Do....................	Sept. 10	12 m......	64.5	46.0	22.028	3.6	24
Do....................	Sept. 10	1 p. m....	66.	46.5	22.018	3.5	22
Do....................	Sept. 10.	2 p. m....	66.	46.5	22.008	3.5	22
Do....................	Sept. 10.	3 p. m ...	68	48	22.000	4.0	23
Do....................	Sept. 10	4 p. m....	68.2	48.5	21.982	4.2	24
Do....................	Sept. 10.	5 p. m....	67	48	21.980	4.2	25
Do....................	Sept. 10.	6 p. m....	65	47.5	21.974	4.4	28
Do....................	Sept. 10.	7 p. m....	51	44	21.948	5.8	58
Do....................	Sept. 10.	8 p. m....	41.5	39	21.946	5.9	80
Do....................	Sept. 10.	9 p. m....	38	37	21.946	5.9	88
Do....................	Sept. 10.	10 p. m....	33.5	33.5	21.944	5.5	100
Top of Jemez Peak	Sept. 10.	Sunrise...	39	31.1	19.910	2.8	41
Do....................	Sept. 10.	12 m......	58.7	40.4	19.973	2.4	19
Do....................	Sept. 10.	6 p. m....	51.7	39.7	19.972	3.9	32
Do....................	Sept. 10.	9 p. m....	45	36.5	19.956	3.8	45

Glancing at the relations of temperature, we find for the air of the valley a difference in one day of 44.2 between the highest and lowest range of the thermometer, the former being reached at 4 p. m., and not at 2 or 3 p. m., as is the case in lower altitudes. While in the valley the minimum was 24°, on the mountains it was 15° higher; but while in the former the thermometer at noon indicated as high as 64°.5 F., in the latter it did not indicate more than 58.7° F.

I have often observed in New Mexico that during the night the temperature of a valley sinks below that of the neighboring height. On first thought this might appear paradoxical and at variance with what we would naturally think, since we would expect that a convex surface, like a mountain, would lose more heat by radiation than one that is concave, like a valley. One might object that the air, having cooled off on the mountain-side, rolls off into the valley and is continuously replaced by another stratum of air not yet cooled to so great an extent; but a glance at the respective conditions of *absolute humidity* in the mountain and valley airs does not, apparently, confirm this view, since it increases more rapidly in the former than in the latter. There must, then, exist currents of a somewhat different nature. Pictet has found that at night the air at a certain height above the ground is warmer than the stratum in direct contact with it. We are, however, left in the dark as to the thickness of this warmer stratum, and as to whether in a mountainous country its existence is not questionable, on account of various currents produced by the unevenness of the country.

In regard to the barometer, we find a minimum immediately before sunrise and a maximum at 11 a. m. Further, a greater difference in oscillation, as should be expected in such an altitude, which is undoubtedly due to the great contrasts in temperature.

In regard to the *absolute* humidity, we find a considerable diminution in the mountain-air when compared with the air of the valley. While in the latter it amounted to 4.5 grams per cubic meter, in the former it was only 3.2. We find also the difference between the maximum and minimum of humidity much greater in the latter than in the former. Further, we find for the valley-air two maxima in absolute humidity, viz, at 9 a. m. and 9 p. m., and in apposition two minima, viz, at 2 p. m. and immediately before sunrise. The dew point was reached every night in these mountains. The moment of the deposition of the dew can be nicely observed by the use of an India-rubber cloth spread on the ground, the slightest film thus becoming visible when no trace of

the beginning of the dew-formation has as yet become apparent on any other object—a fact due to the lesser porosity and non-hygroscopical qualities, linen, grass, &c., absorbing the aqueous vapor when in commencement of condensation. In this way I frequently compared the actual dew-point with the calculated one, and found in many instances a difference of several degrees, dew making its appearance and being visible sooner on the rubber-blanket than can be calculated from the psychrometer-observations. This, however, should not surprise us, if we take into consideration the fact that poor conductors of heat, like rubber, cool off more quickly than the air when left to radiation, and that they have reached the calculated dew-point when the air is yet from 3° to 4° warmer. To what extent the more or less sinking of the nightly temperature depends in these mountains on the absolute humidity of the air may be evident from the following observation: On the afternoon of the 13th of September, a heavy thunder-storm occurred, but toward evening the clouds dispersed. The absolute humidity late in the evening was 8.1 gram per cubic meter, and the next morning the temperature was 45°. On this latter day (September 14) the air rapidly gained its average normal dryness, and the absolute humidity in the evening was 4.0; therefore the fall of temperature was exceedingly rapid during the night, the thermometer standing the following morning at 23° F.

It appeared to me interesting to compare the dryness of the air of New Mexico with that of other countries and climates. In this comparison I found that in a number of instances, in my own observations, the *absolute humidity* was lower than any observed in hot and temperate zones. Some of my own observations are given in the annexed table, alongside of those of Humboldt, D'Ahaddie, and Rohlfs, made in the Asiatic and African deserts. The *relative humidity*, it is true, is in a number of cases in the air of the desert of Sahara still lower—even as low as 6 in one instance; but this is explained by the fact that the temperature of the air was in such cases as high as 122° F., (50° C.;) but *absolute humidity* has never been found as low as in the air of New Mexico.

Date.	Time.	Locality of observation.	Thermometer.		Barometer.	Humidity.		Remarks.
			Dry.	Wet.	Inches.	Absolute.	Relative.	
September 17, 1874	4 p. m.	Head of Cañon Chaco	74° Fah.	49° Fah.		1.9	9	Calculated dew-point at —16° C.
	7 p. m.	do	61° Fah.	43° Fah.	23.214	2.5	18	Sky clear; strong west wind.
	8 p. m.	do	59° Fah.	42° Fah.		2.7	21	
September 18, 1874	6 p. m.	Pueblo Bonito	53° Fah.	37° Fah.	23.520	1.9	18	Sky perfectly clear; strong west wind; dew-point —22° C.
September 19, 1874	6 a. m.	do	27° Fah.	21° Fah.		1.3	28	
	8 a. m.	do	47° Fah.	34°.8 Fah.		2.2	24	
November 7, 1874	6 p. m.	Sierra de Santa Fé	32°.4 Fah.	22°.1 Fah.	21.178	1.3	23	Sky perfectly clear; west wind.
August 5, 1829		Siberian Desert, Platowskaya	23°.7 C.	12°.7 C.		4.0	18	Humboldt, observer.
March 1, 1845		Quarata, in Abyssinia	26°.2 C.	15°.7 C.		6.3	24	D'Ahaddie, observer.
March 11, 1866	Sunrise	Murzuck, in North Africa	23°.0 C.	11°.3 C.		3.13	13	Rohlfs, observer.
January 13, 1866	3 p. m.	do	22°.2 C.	10°.5 C.		2.48	12	do.

TEMPERATURE OF RIVERS AND CREEKS.

This is a subject to which heretofore but little attention has been paid, although it has not only scientific interest, but also practical importance in connection with fish-life. The temperature of the streams is by no means changing as rapidly as that of the air; but the variations remain between respectively small limits—the more so with the larger bodies of water. (See temperature of the Rio Grande in the table.) The temperature of the water rises and falls but slowly—a fact due to the great capacity of water for heat. Fish-life naturally depends much upon the range of temperature of the water, different species requiring different temperatures. In 1874 I paid special attention to this subject, comparing the relation of temperature with the volume of the stream and the fish-life in it. The results of my observations are given in the annexed table. In this we find the Rio Grande has a remarkable uniformity of temperature, although the observations extended over a period of three months and were made at places a hundred miles distant from each other.

The temperature of the springs encountered at different altitudes was also taken, and is as follows:

Locality of spring.	Spring temperature.	Air temperature.	Altitude.
Wet Mountains	42° Fah.	58° Fah.	9,400
Rosita	48	60	9,000
Greenhorn Mountains	52	63	6,000
San Juan range	46.5	60	9,300
Cañon Canjelon	55	62	6,100
Valle Grande	56.5	24 and at 66	
Jemez Mountains, 1	63	Taken at sunset and sunrise.	Average altitude of 9,000 feet.
Jemez Mountains, 2	67		
Jemez Mountains, 3	82		
Jemez Mountains, 4	84.5		
Jemez Mountains, 5	105		
Ojodel Alto, (Mesa de los Lobos)	49	44	6,900
Willow Springs	51.5	61	6,400

From the above table it will be seen that the temperature of all the springs of the Jemez Mountains and Valle Grande is above the average of that of the springs of such an altitude.

Name of river.	Date.	Dimensions.		Altitude.	Time of observation.	Temperature of—		Remarks.
		Depth in feet.	Width in feet.			Water.	Air.	
Rio Grande, (at Colonas)	Aug. 19	4	60	6,900	Sunrise	61.2	49	Water clear; current swift; fish plentiful.
	Sept. 2	3	80	5,600	Sunset	66	60	Observations near the town of San Juan.
	Sept. 3	3	80	5,600	Sunrise	60.5	46.5	
	Oct. 1	3	250	5,100	4 p.m.	65	76.5	Observations near Peña Blanca.
	Oct. 2	3	250	5,100	Sunrise	58	46	
Rio Chama	Aug. 29	2	15	6,000	Sunrise	62	57	Muddy water; bed sandy. Observations near Abiquiu.
	Aug. 29	......	......	......	Sunset	67	70	
	Aug. 30	......	......	......	Sunrise	64	61	
	Aug. 30	......	......	......	2 p.m.	71	75	
	Aug. 31	......	......	......	Sunrise	63	57	
	Sept. 1	......	......	......	Sunrise	62	56	
Rio Puerco	Sept. 26	1	6	6,100	4 p.m.	71	74	Muddy; no fish whatever. Observations made near San Ignacio.
	Sept. 27	......	......	......	Sunrise	46	41	
Rio Polvadera	Sept. 6	½	5	7,300	2 p.m.	66	68	Trout abound. Observations near Abiquiu Peak.
	Sept. 7	......	......	......	Sunrise	44	34	
Jemez Creek	Sept. 28	½	10	5,000	Sunrise	47	46	Very shallow and sandy; no fish.
Rio del Oso	Sept. 4	¼	2	6,200	4 p.m.	71	76	No fish.
	Sept. 5	¼	2	6,200	Sunrise	44.5	41	
	Sept. 5	¼	2	7,600	2 p.m.	51	66	Observations nearer the sources, in a narrow, well-timbered cañon.
	Sept. 6	¼	2	7,600	Sunrise	42	43.5	
Ojo Caliente Creek	Sept. 1	½	8	6,000	4 p.m.	76	86	Few fish.
Obsidian Creek	Sept. 10	1½	3	9,000	Sunrise	54	24	Trout abound; suckers also occur. The springs from which this creek is formed, have all unusually warm water for this altitude.
Obsidian Creek, (on the Jemez Mountains)	Sept. 10	1½	......	9,000	Sunset	56	60	
San Antonio Creek	Aug. 20	1½	10	8,000	Sunset	64	63	Many deep holes in the river, which is shut in, to a great extent, in deep basaltic cañons. Suckers, trout, and white-fish are seen.
	Aug. 21	1½	10	8,000	Sunrise	57	47	
	Aug. 21	1½	10	8,150	2 p.m.	59	67	Observations made about four miles farther up.
	Aug. 21	1½	10	8,150	Sunrise	57	40	
Costilla Creek	Aug. 19	1¼	7	7,200	Sunrise	54.5	55	Suckers seen.
	Aug. 19	......	......	......	2 p.m.	69	75	Rainy weather at the time of observation, in the morning.
Tributary of the Brazos	Aug. 24	½	2	9,200	Sunrise	44	40	No fish seen. Observations made in the San Juan range.
	Aug. 24	½	2	9,200	Sunset	42	58	

APPENDIX H 1.

PRELIMINARY BOTANICAL REPORT, WITH REMARKS UPON THE GENERAL TOPOGRAPHY OF THE REGION TRAVERSED IN NEW MEXICO AND ARIZONA; ITS CLIMATOLOGY, FORAGE-PLANTS, TIMBER, IRRIGATION, SANITARY CONDITIONS, &C.: BY DR. J. T. ROTHROCK, ACTING ASSISTANT SURGEON, UNITED STATES ARMY.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS
WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., June 30, 1875.

SIR: I have the honor to transmit the following preliminary report upon the work intrusted to me during the field season of 1874.

The enumeration of the plants, with critical notes, and with descriptions of the new species, is reserved for the final report, which is to consolidate into one volume the entire collection from 1871 to 1875 inclusive. I am induced to do so, with your permission, because the interval between the field seasons of 1874 and 1875 is too short to complete the naming of the material now on hand; and because its consolidation will produce a work full enough to serve as a manual of botany for the country from the fortieth parallel south to the Mexican boundary. and corresponding with the meridians of the main mountain axis of the continent with their adjacent mesas and plains. Such a work is now greatly needed.

In addition to the merely technical and botanical features of the proposed report, there will be added much material of direct economic importance, and which is, perhaps, more intimately connected with the duties of the botanist than with those of any other member of the survey; *i. e.*, the general topography of the country, some statement of its climatology, the relations of the forage-plants and timber to the present and prospective wants of the nation, as the region is opened to settlement, the probable increase in agricultural areas under cultivation and irrigation, and a system of tree-culture, and the sanitary conditions of the country as influencing immigration.

In obedience to instructions received from you, our natural-history party, consisting of Mr. H. W. Henshaw, J. M. Rutter, and myself, left Santa Fé, N. Mex., June 26, 1874, going thence via Albuquerque to Fort Wingate in New Mexico, thence to Camp Apache, Arizona, from there to Camp Grant, and next to Camp Bowie, reaching our most southern point in the Sanoita Valley, twelve miles below the now abandoned site of Camp Crittenden, and hence nearly to the Sonora line. Returning we came via Camp Lowell, near Tucson, to Camp Grant, and thence via San Carlos over the trail to Camp Apache, reaching it October 9. Here a side trip was made to the summit of the Sierra Blanca. Though late in the season, important scientific results were derived from this trip.

November 1 we left Camp Apache for Fort Craig, on the Rio Grande, distant one hundred and ninety miles. Our route lay by the now abandoned post at Tulerosa. From Fort Craig to Santa Fé the road is through a country much traveled and well known. We reached Santa Fé, on the return, November 22.

For the sake of convenience in this report, I will follow the route above indicated, taking each of the points mentioned somewhat as a center for the remarks on the botanical resources of the regions traversed.

Santa Fé, at an altitude of 7,044 feet above sea-level, was in June probably looking its best. The mountains back of the city are made up largely of a coarse-grained red granite with many veins of quartz, some of which contain varying quantities of silver, gold, copper, and lead. The slopes of the main axis show the Carboniferous rocks, and some remains of the Cretaceous. The whole aspect of the country impresses one with the important part erosion of the surface has played.

As might be supposed, the soil on the level ground approaching the Rio Grande is such as would result from a mingling of detritus from the formations above named, *i. e.*, lime, sand, and marl. Hence the soil can hardly be considered as unproductive from absence of the elements of fertility.

The limited area of agriculture near Santa Fé is determined by scarcity of water. These remarks are made at the outset, for they may be considered as having some application to the route, as far at least as Fort Wingate.

On the low foot-hills between the city and the mountains there is a sparse growth of a dwarfed, branching, pine. It is the piñon of the natives and a form of *Pinus edulis*, Engelm, of the botanists. It is prized as much for the edible nuts it furnishes as for the fuel it supplies. The quantity of the terebinthinate it contains makes this wood burn with a very hot and rapid flame. Associated in about equal quantity with the piñon is a cedar, equally low and branching, but valuable for fencing purposes, &c. Farther back on the mountains there is a limited supply of pine and fir, (principally *Pinus ponderosa*, *Abies Douglasii* and *Abies concolor*.) There is, however, probably enough to meet the demands for many years. Immediately around the town the pasturage is kept nipped off close by the stock that is turned out to seek a living as best it may.

Hence, to supply the town demand, forage is packed in on the backs of "burros." The supply for the military post (amounting to several hundred tons a year) is hauled from a considerable distance. Much of it comes from Galisteo. Quite a considerable portion of this (for the town) is supplied by a remarkable-looking grass, (*Stipa pennata*, L., var.,) which we afterward found growing abundantly on the mesas toward Fort Wingate, at about the same altitude as Santa Fé. Besides this there is another peculiar-looking grass, (*Aristida*,) which furnishes a scant forage.

The primitive methods of irrigation are wasteful in the extreme, and actually limit the productions to below the real capacity of the region. There does not appear to be much attempt made in the way of fertilizing the soil. Under these circumstances, it is fair to infer that better habits of agriculture will produce larger results in and about Santa Fé. There are two model-gardens within the city limits, and their abundant returns of vegetables and fruits show something of the real capacity of the soil. To make one statement: I should say that, from Santa Fé, south, apples, peaches, plums, apricots, and probably pears, would do well. in the Rio Grande Valley. Taos, near the Colorado line, has long been known as a wheat-producing region.

Though rather out of place, I would remark that in certain portions of Colorado and New Mexico a plant has for years been known to exist which is quite destructive to cattle eating it. From the symptoms, it was conjectured that this plant was aconite. It has been rendered pretty certain that the offender is a plant known to botanists as *Oxytropis Lamberti*. It is quite common on the plains and the lower mountains, growing somewhat less than a foot high, with flowers at first purplish blue, then fading to yellow. The cup holding the flower is covered with a silky down; the flower-stalk is leafless, and about 8 inches high; the leaves, divided like those of the locust, though smaller, are clustered around the base of the flower-stem. It has recently been discovered by Dr. Vasey that two related plants (*Astragalus Hornii* and *A. lentiginosus*, var. *Fremontii*) have a similarly bad reputation in California.

Leaving Santa Fé behind us, there were here and there, along the road to Pinos Ranch, a few very small fields under cultivation. They were sparingly supplied with water from a little and rather uncertain stream. Quite a number of herds were seen grazing on the adjacent hills.

At Pinos Ranch (at the time of our visit) the supply of water was limited to one little spring. It probably, with some other water-holes in the vicinity, was sufficient for the inhabitants and their cattle, but left all idea of irrigation out of the question. There was an abundance of good grass scattered over the neighboring country to support many cattle. The prevailing character of the country, however, was that of a sage-brush plain, dreary and uninviting. From this point to the Rio Grande at San Felipe there was no improvement; water was wanting.

Reaching the river, farming again became possible. The Pueblo Indians were busily engaged (as we passed) in their fields, and their crops looked quite well. From these Indians a large portion of the wheat and corn used in Santa Fé comes.

In addition to the fruits already alluded to in connection with Santa Fé, the vine put in appearance at San Felipe, and from this, as far south as we went down the Rio Grande Valley, (to Fort Craig,) it was everywhere one of the leading objects of culture. The wine is of good quality. It is currently reported that immense quantities of the grape-juice are each year lost for want of better knowledge in its preparation. It is fair to say that the wine of the Rio Grande will now compare favorably with that of California. In the one instance, as in the other, a greater age is needed.

From Algodones to Albuquerque the valley is covered with alluvial soil and with drift, probably from the Zandia Mountains, which are on the eastern side of the river. This fertile flat has a varying width, at some points being over two miles wide. Rocks of the upper marl series are occasionally noticed *in situ*. West of the river, and almost to its edge sometimes, are portions of the great overflow of basaltic lava which poured forth from the San Mateo Mountains, some fifty miles farther to the west.

At Albuquerque the alluvial flat is quite wide. A crowded population has utilized every portion of it, and the innumerable irrigating-ditches show how close is the economy of soil there. Just previous to our reaching the town an unusual rise had taken place in the river, owing to a rapid melting of snow in the mountains at the river-heads.

The entire flat above Albuquerque was submerged, causing great destruction of property, and even threatening the safety of the town. *The freshet was a most unusual one.* It may, however, have brought to the soil enough of fresh material to compensate for the damage.

There was frequent occasion to observe the protective influence of the vegetation. At the point where the "arroyos" from the hills opened out into a sort of funnel on the flats, the "chico" clumps had retained the soil about their roots until the shrub remained standing on a mound 2 feet high, from around which the whole surrounding surface had been washed away.

Crossing the Rio Grande at Albuquerque, our course lay westward to the Rio Puerco—about fifteen miles. We were obliged to cross a considerable divide in going from one

stream to the other. The hills were sandy, covered with a very sparse growth of grass, a *Bigelovia* "*chico*," *Atriplex acantho carpa*, a depauperate acacia, and the inevitable sage-brush. An occasional dwarfed piñon-pine managed to survive. Large herds of sheep and cattle from the Rio Grande range some distance back, and pick up a living. As a supplementary pasturage to the river-flats, this divide is of value, but it can never be turned to any purpose of agriculture. In a word, the region along our route from Albuquerque to McArty's ranch is unquestionably the most unpromising portion of New Mexico that I have seen. The sand along the road to the Rio Puerco almost entirely hides the subjacent rock, but we did get an occasional glimpse of the white concretionary stratum beneath.

At our crossing-point, the Rio Puerco has worn out a deep channel in the alluvial soil, which is there quite thick, and indicated abundant fertility, if water in any quantity were present. In the latter part of June, however, the bed of the river was absolutely dry, save where the water had accumulated in the deeper holes. This supply is quite too precarious to admit of herding there during the drier portions of the year. The solitary Mexican family we found at the bridge was about ready to leave and seek water elsewhere.

From the Rio Puerco to El Rito the country was even less prepossessing than that we had gone over. The same arid, treeless waste of country was spread out before us. "Sheep Springs," indicated on our map, naturally enough suggested water; but on reaching the point we found a little, percolating drop by drop into the hole dug for its reception. This, too, was so alkaline, that neither man nor beast could use it. There is doubtless a better supply here at other times, but it is precarious at best.* There is a marked outcrop of saliferous sandstone near the spring. The purgative properties of the water appear to be very decided; nothing but extreme want could induce us to use the water. At El Rito, the San José, like the Rio Puerco, into which it flows, (when there is water,) was absolutely dry. The town contained a population of several hundred people, all depending, so far as we could learn, on a single well, at which we were obliged to *purchase* water for our animals. The crops were perishing from the drought. The soil, however, was fertile.

Laguna, two miles west of the town, has a large spring, but markedly alkaline; still, as it was cool, we made it quite refreshing by the addition of citric acid. The Pueblo Indians were herding their flocks near by the water. Pasturage was good and abundant in the adjacent hills. The pueblo was two miles farther on. It was well supplied with water from a large spring that came gushing out of the cañon-side, immediately under the basaltic trap. It was cool, and almost free from alkali.

From this place almost to Covero we traveled through an alluvial valley, the soil of which was quite fertile, and evidently was fully utilized by the Indians for farming and grazing purposes. It was alkaline, and in many places quite covered with the characteristic white deposit. There was an abundance of grass of two kinds, chiefly *Brizopyrum spicatum*, which was eagerly eaten by the mules, and the other, *Sporobolus cryptandrus*, only when no better could be had. The latter grew by choice only in the most alkaline soils. It was hard in its tissue; evidently relished by the "burros," but the mules, after nipping off the tops, would leave the rest standing untouched.

Covero is situated over a coarse, yellow sandstone. Immense bowlders lie scattered over the surface. A good spring of *pure water* bursts out of a crevice in the rock near the center of the town. This alone could have determined its location on so forlorn a spot. There are some signs of cultivation of the soil; but what the attending success is I am unable to say. McArty's ranch is eight miles beyond. Here the pasturage is fair, and water abundant. Timber, too, is near enough to add to the advantages of the situation. We saw some rather unpromising wheat and corn under cultivation as we passed. There is plenty of good alluvial soil near enough to the water to make some productive ranches in that vicinity, and drainage will reclaim some that are now in swamp. As usual in such places, the adjacent hill-sides will support large herds.

Following the stream up, we found that for several miles it was flowing through and over a recent lava-bed that originated in the vicinity of old Fort Wingate, or from the San Mateo Mountains. It had evidently been poured out since the country had been eroded, and assumed its present configuration, following down the course of this same stream, turning its water into steam, which became entangled in the mass, and filled the cooling lava with cavities like pumice-stone, or like a sponge. This same lava-overflow has an appearance so fresh, with the waves and ripples formed and chilled, that it has attracted the attention of all who have passed over the ground. A large, slightly alkaline spring rises out of the lava, and is apparently the main feeder of the stream below. Its water is not cold. The vegetation of the lava-bed is quite unlike that on either side of it. Rank sedges and rushes covered the ground where there was enough of standing water to make a congenial home for them; and in such places the mosquitoes and flies literally swarmed.

* Since writing the above, I have been informed of the existence of a spring about a mile to the south of Sheep Spring. This, of course, increases the probability of successful herding at that point.

We could see the snow still remaining in the gulches on the side of the San Mateo Mountains, (July 2.) The distant hills began to be better timbered, though with what species of pine and fir I was not able to determine from the road.

From this point to Fort Wingate the whole appearance of the country undergoes a change for the better. Taking the country with its capacities, for ten miles on either side of the road, I am persuaded that in no distant future it will support a large grazing interest.

At Agua Azul there was still enough water remaining in holes along the water-course for the cattle. A good well, too, supplemented this supply. The spurs of the Zuñi Mountains, within easy reach, furnished all needed timber, and even on the flat grounds beautiful clumps of piñon-pine were becoming much more abundant.

The site of old Fort Wingate (a few miles to the south) is said to furnish abundant water and forage. Good arable land is also reported there.

At Agua Azul some seed of "red-top" grass, sent from the East, *was said to have been sown in March*. In July I saw it over 2 feet high and well matured. The grass (*Stipa pennata*, L. var.) which we saw for sale at Santa Fé was found growing quite abundantly on the table-land between Agua Azul and Bacon Springs. Associated with it was another grass, (*Pleuraphis Jamesii*,) eagerly eaten by our animals. There can be no doubt as to the value of the region intervening between the two points above named as a stock-raising center. It will produce an abundance of forage, during part of the year at least, for thousands of cattle.

Crossing Campbell's Pass, we passed, almost without knowing it, from the waters of the Atlantic to those of the Pacific slope. The altitude of the plain at the divide is 6,952 feet above the sea.

Approaching Bacon Springs, we were, for the first time since leaving the Raton Mountains, in Southern Colorado, fairly face to face with timber of good size.

The absence of *any marked divide* at the pass we had just crossed allowed such an interchange of plants that there were no points of contrast in the eastern and western floras.

Leaving Fort Wingate for Camp Apache, in Arizona, our course lay more to the south. Thence we crossed the Zuñi Mountains immediately back of the post. Our ascent lay through dense forests of pine and fir. The wants of the fort have, however, somewhat thinned it out, at least of the best timber.

Gaining the summit, a thousand feet above Fort Wingate, we were at an altitude of about 8,000 feet above the sea, a fine open, park-like region, with a large growth of yellow pine (*Pinus ponderosa*) and fir covering the hill-sides. A diversified herbaceous vegetation was out in the most brilliant colors, beautifying alike the woods and open grounds. It was a perfect garden of *Pentstemons*, and among them, for the first time on the journey, we saw the most striking of them all, *P. Torreyi*. Already the flora had fairly assumed a southern aspect. Arcenthobiums on the pines and mistletoes on the oaks became, among other new features, at once a predominant element of the vegetation. Amid such a wealth of flowers, we could for the time forget the weary, dreary country we had passed through. Good forage was abundant.

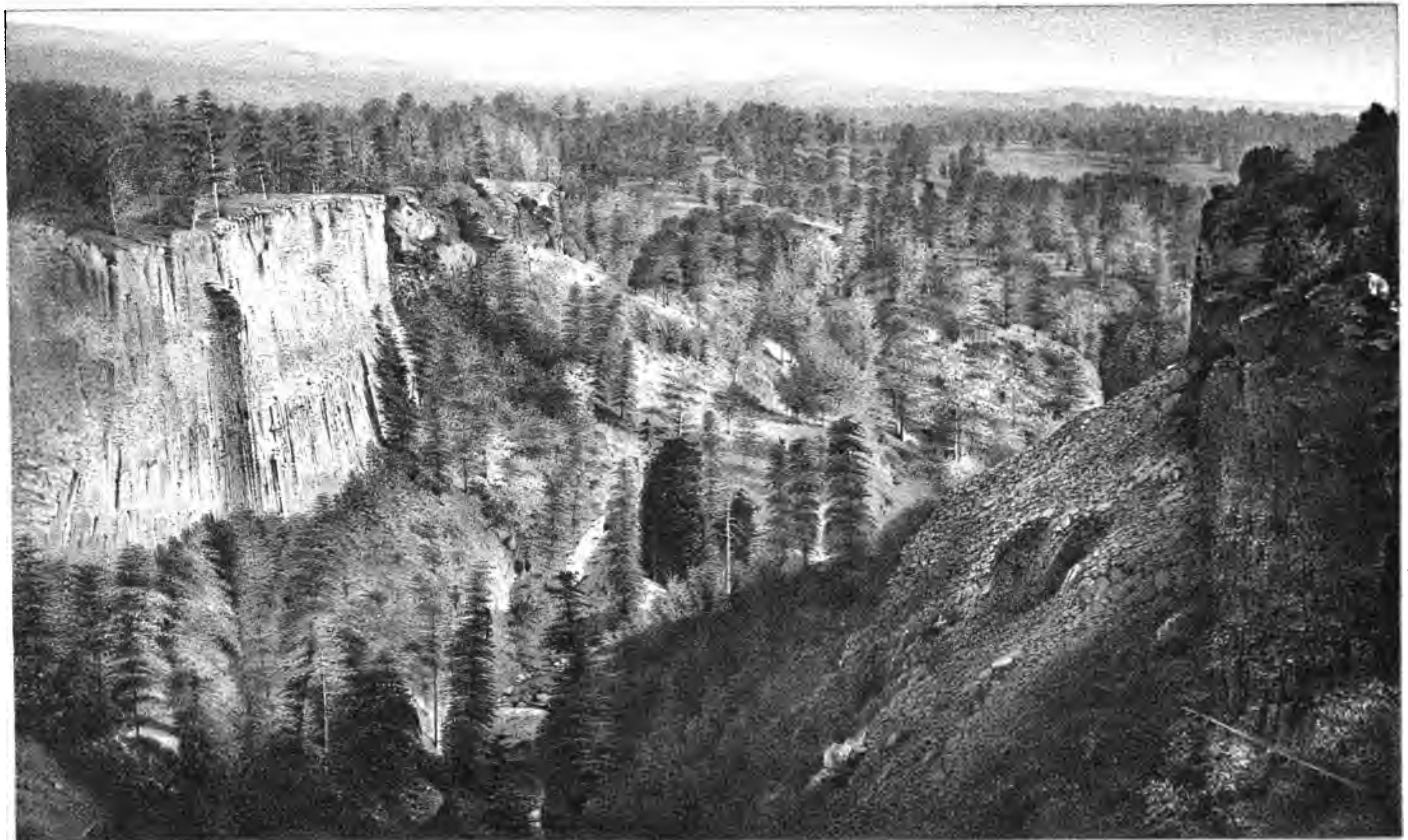
Descending the southern slope, we passed through oak groves, and finally entered a winding valley, camping for the night at a spring which is one of the heads of the Zuni River. The Navajo Indians had here large herds of cattle, sheep, and horses, all looking as though they found abundant nutriment in the grass of the region. Timber continued in abundance on the hill-sides a few miles south of this. By the time we had reached Pescado, it was again dwarfed in size and less abundant. An altitude of less than 7,000 feet is at once manifested in the country by the depauperate remains of what were, at from 8,000 to 10,000 feet, magnificent forests.

From Pescado to several miles south of the Zuñi town we saw, every little while, a herd of cattle, a band of sheep, or a well-cared-for field, belonging to these industrious Indians. Along the river they had utilized every foot of the soil they could irrigate, and their crops were the best we had seen. On the table-land, a few miles south of their village, we saw the first fair-looking crops growing without irrigation. Apparently, this point was a center of surface-drainage, and a substratum of clay made the soil more tenacious of its moisture. During July and August there is a well-marked rainy season here. The rain is precipitated in torrents, and most effectually sets at rest all doubt as to the rain-fall *in those months*. The vegetation, already languishing under the intense heat, revives, as if by magic, and presents a verdancy the more cheering by contrast with its parched appearance a few days before. We experienced a severe hail-storm, that, if a regular accompaniment of the rainy season, must at times do great damage to the growing crops. In fact, we saw some that were actually beaten flat by it.

Near Deer Spring, in Arizona, the country became better timbered again, piñon and cedar covering the lower grounds, and larger pines the higher. In fact, the general appearance of the region promised well for its future.

A deserted ranch at Deer Spring indicated that this desirable locality had not passed unnoticed. There is an abundance of good water, with a strip of meadow-land

PLATE VII



T. Sinclair & Son, lith. Phila.

NORTH FORK CAÑON, WHITE MOUNTAIN CREEK, ARIZONA.

that, when once drained, could be made very productive. For several miles south of this place the road lay through a valley from two to ten miles wide, the surrounding mesas absolutely hemming it in on all sides with their precipitous walls. Skirting the edge of this valley there was a fair supply of timber, and at several points springs appeared at the bases of the mesas. The soil, though in some places somewhat alkaline, was absolutely black with decaying vegetable matter, and seemed in point of fertility like a vast mass of compost. It certainly is a fine situation for herds at any season of the year, and might even prove a favorable farming location, though on this point I am unable to speak with certainty. From the abundance of water on the sides of the valley it is not improbable that water in abundance could be had by digging.

Twelve miles south of Deer Spring the scene changed, and we entered a waste of sand-hills, which stretched off south to the Little Colorado. They were covered with the usual desert growth of grease-wood, sand-grass, and sage-brush. An occasional clump of piñon pines survived the desperate struggle for existence, serving to show at least how hardy the tree is.

The Little Colorado is, where we crossed it, a deep, narrow stream, with water enough for irrigating purposes; hence the immediate valley may be regarded as belonging to the domain of agriculture. In July the heat of the sand-hills on either side is almost intolerable. Nearer its head, the river drains a valley that now produces fair crops of corn and barley. The proximity of the Sierra Blanca, with their accumulated winter snows melting away until late in the spring, and the frequent showers of July and August, make a certainty of the water. Indeed, near the base of the mountains irrigation might almost be dispensed with, so frequent are the showers. We will allude to this region farther on.

Cave Spring is fifteen miles south of the Little Colorado. The water comes flowing out of the base of the basaltic lava, as is the case with the best springs of the country. As usual, the meadow through which the stream ran had its crop of sedges and rushes, and, in the course of ages, had become quite fertile from the successive crops of vegetation that decayed there. The adjacent hills were well covered with bunch and grama grasses, notwithstanding the roots had often to penetrate into the crevices of the lava for nutriment.

Piñons were sparsely scattered over the country. As a grazing center, this is a desirable location. From this to the bottom of the timber-belt on the Sierra Blanca the road was through a region in which thousands of cattle might roam and find enough of forage most of the year. Water is within easy reach.

Arizona is, emphatically, a land of contrasts in scenery; its tropical climate either parching the soil and vegetation, or, under a fair supply of water, causing the flora to deck the surface with a luxuriant covering of verdure. Nowhere is this statement more strikingly true than in the Sierra Blanca and the adjoining plains to the south. On the latter, the *ensemble* of the vegetation is dwarfed and hardened from the aridity of the soil and the rapidity of evaporation. In the mountains, however, dense forests alternate with well-watered glades, covered with a luxuriant growth of grass and flowers. The succulent tissues of the herbaceous vegetation appeared by contrast with the harder plants of the plains to show an excess of vitality; and an abundant nutrition, expansion into leaf, instead of contraction into the least possible evaporating surface, is characteristic of the rank, luxuriant growth of the Sierra Blanca. Rising from an altitude of 5,000 feet above the sea to 11,388 feet, and between the 33d and 34th parallels of latitude, we have climate superimposed on climate, from one as dry and hot as that of Sahara to a warm-temperate, a temperate, and a subalpine. The flora of the region ranged from the cacti and acacias of the lower grounds to the asters, golden-rods, and piñon pines of the middle, and, after crossing the belt of the *Pinus ponderosa* and large firs, disappearing with dwarfed firs and a helenium on the summit of the Sierra Blanca.

Standing on this elevated peak and looking over the surrounding region, one of the most striking views on the continent is unfolded. Ridges run in all directions from this culminating point, and descend through a stretch of miles like so many radii in an immense circle. They start from a mountain mass of infinite grandeur and dwindle out on the grassy flats from 2,000 to 4,000 feet below. Between them are well-watered valleys, producing grass enough for all the herds of the Territory. Plains rich in all the glory a wealth of autumn-coloring could confer on their herbaceous vegetation, belts of golden-colored cottonwoods, deep and somber forests of evergreens, contrasting, yet harmonizing, combined to complete this perfect landscape. The impress upon the mind of such a view is final, and can never be forgotten. Where the ridges proper ended, the general slope of the country had been cut into cañons, each a tributary channel for carrying the torrent of water made by the melting snow to the main stream. Erosion could here be detected, illustrating to us the wonderful history of our western domain. The mesas thus left between the cañons were topped with the ever-present trachytic overflow.

Water and fire, each supplementing the other, had impressed the final features on the country. (See Plate VII.)

It is certainly within the limits of safe prevision to assert that, as this portion of Arizona and the adjacent parts of New Mexico are rendered more safe from Indian depredations, and more accessible to the immigrant, settlers, attracted by its soil and climate, will flock in to occupy it. From the summit of Sierra Blanca, looking to the east, mountains of low altitude, with fine valleys between them, rise, one beyond the other, for at least sixty miles; and most of the territory embraced in the area represented a combination of valuable timber, grazing, and farming lands. Above 7,000 feet we can hardly expect that agriculture will become a dominant interest. Above this, however, is just where the best timber and summer cattle-range is found. At Willow Spring (altitude 7,195 feet) the snow occasionally is several feet deep, and hence wintering stock there is out of the question, except in an unusually open winter. It is a safe assertion that there is on the Sierra Blanca of Arizona enough of good pine timber for the whole Territory for many years. *Pinus ponderosa* attains a height of 70 feet, and some of the firs reach a greater height. An oak, (*Quercus undulata*,) in general appearance somewhat like our white oak, grows abundantly over this region. (See Plate VIII.) It does not exceed 25 feet in height, and the trunk is much branched. The wood is "close-grained" and solid; hence it may be of considerable service in the future of the country. Bunch and grama grasses, along with others, the nutritive qualities of which are not so thoroughly recognized, grow luxuriantly everywhere, and it would be hard to overestimate their importance in a Territory the general reputation of which for fertility is as bad as that of Arizona. Lest I should be misunderstood, I will qualify these statements on the Sierra Blanca district by saying that I do not speak of its resources as compared in general with those of the surrounding regions, but intend my remarks to be taken absolutely; *i. e.*, the district would in any portion of our dominion be regarded as one of unusual promise. It is one of the most inviting portions of our country yet remaining for civilization to occupy. A large portion of the hay for winter-use of Camp Apache comes from the vicinity of Willow Spring. The mesas on either bank of the White Mountain Creek, and in sight of the post, furnish all the pasturage requisite for the Government animals, to say nothing of the hundreds of Indian ponies, whose owners belong on the reservation. Good crops of corn are grown on the alluvial flats in the valley, even under the slovenly culture of the Indians. The post garden is an exponent of the capacity of the soil under better treatment. It furnishes to the troops stationed there the ordinary vegetables of our eastern market. The altitude of Camp Apache is 4,925 feet. My attention was called at the camp to one of the spreading euphorbias which grow so abundantly on the dry ground. It is a reputed remedy for the bite of the rattlesnake, and the Indians appear to place implicit confidence in its virtues. It is evidently one of the prostrate forms known to the natives as Yerba de la Golondima. It is used, in the form of tincture, as a local application in snake-bite by the Mexicans. I have had no opportunity of testing its efficacy, nor do I know of any reliable observations bearing on this point. It is well, however, to remember that popular ideas that are so widely spread and generally believed have usually enough of truth in them to commend them to the serious attention of competent observers. In this special case, however, it is somewhat difficult to understand how a mere topical use of the remedy is to act on a poison which has already gone into the general circulation.

The region from Camp Apache for thirty miles south, either by the San Carlos trail or the Camp Grant wagon-road, is largely mesa-land, with an average elevation of 800 feet above Camp Apache.

The lava overflow darkened the surface everywhere until we approached the Gila Valley. Grass, though by no means abundant, was of good quality.

The same pines and oaks we have before alluded to in connection with the Sierra Blanca were still common, and grew to a good size. The small walnut (*Juglans rupestris*, var. *major*) was first seen at Rocky Cañon. In the same region the Nezundo was first observed, usually standing alone out on the dry plain. The buttonwood (*Platanus racemosa*) grows quite abundantly along the sandy water-courses, becoming a beautifully-branched tree, a foot or more through, with a height of 40 feet. Between Camp Apache and the Gila River water sufficient for irrigating purposes was only seen at Prieto fork. It did, however, exist at several points abundantly enough for herding. In almost all the numberless cañons which cut up the surface of the country it remains standing in pools, pure and fresh, though warm, the year through, and for a portion of the year, at least, flowing streams course down many of them.

Crossing the divide between Ash Creek and the Gila, a marked change comes over the scenery as we go south. One by one the familiar forms of plants disappear, and in their stead we have the mescal, (*Agare Parryi* and *Palmeri*;) mesquite, (*Algarobia glandulosa*,) from which the mesquite gum is derived; *Dasylirion*, creosote-plant, (*Larrea Mexicana*;) *Fouqui era*, and giant cactus, (*Cereus gigantus*.) A more forlorn-looking vegetation can hardly be imagined. It was observed, in descending the divide to the Gila, that the giant cactus grew by choice on such ground as gave an eastern exposure. Cottonwood trees of fair size grew quite abundantly along the Gila River, where, with willows, bulrushes, and the large reeds, an almost impenetrable thicket is formed.

PLATE VIII.

T. Sinclair & Son, lith. Phila.

OAK GROVE, WHITE MOUNTAIN RANGE, ARIZONA.

The only forage was found on the low-lands, and then consisted largely of the hard, innutritious "saccatone," which appears to have crowded all other grasses out. It contains in its tissues so much mineral matter that it is impossible to cut it with a mowing-machine without ruining the implement. The mules will not touch any part except the tops, if they can find other forage. The whole valley has a "baked" appearance, and the atmosphere, tinged with a half-cloudy redness, can be seen rising in tremulous waves from the superheated surface.

The valley of the Gila at our crossing of the river is 2,517 feet above the sea; hence, in coming from Camp Apache we had descended 2,408 feet. Camp Grant, about thirty miles south in a direct line, is 2,336 feet higher than the river, so that there is a marked sloping of the country from north and south toward this stream, which fact must not be lost sight of in considering its peculiar climatic conditions. Its sandy soil, its rapid evaporation, the dryness of the ridges parallel to the river, together with its greatly lower altitude, impress of necessity upon the flora the peculiarities which contrast so strongly with that of the surrounding region. Yet it is but just to state that this valley in many places produces fair crops of barley and corn. There is enough of water for irrigation of the adjacent low-lands, and this rescues even the soil of the Gila Valley from hopeless sterility. Indeed, at the very point of our crossing there are evidences in some ruins that a large population of semi-civilized Indians subsisted on the productions of this region in the past.

At Camp Goodwin (now abandoned as a military post) we found a luxuriant field of corn and potatoes. As to the quality of the latter, I would remark that I never tasted better. Melons, onions, and cabbages of the best quality swelled the list of productions. Grass was scarce, but by clearing away the growth of rank weeds that infested the ground, and protecting it from stray animals, the soil would yield good crops of grass or of any of the cereals. This place is capable of being transformed into a garden. Its worst feature is the unhealthiness of the climate. In fact, it was on this account abandoned by the Government authorities. Drainage would do much toward improving the location in this respect.

Between Camp Goodwin and Cottonwood (nineteen miles) the agricultural resources are reduced to a minimum, and, except at one or two points along the route, even grazing to any considerable extent is out of the question. Water may be found, possibly, at some points off the line of march; but unless it is, there is nothing to invalidate my statement as to the general worthlessness of the country.

At Cottonwood we found a creek-bed, with some water remaining in a few scattered pools, at which the stock found enough to supply their wants; but herds of any size would have exhausted this precarious supply.

There was an abundance of grass on the hill-sides, which would, during the portions of the year *in which water could be found in sufficient quantity*, make this a good grazing center. It was observed that the milk was almost unfit to drink, owing to some plant (probably an artemisia) that the cows had been eating. This, we afterward found, was not an unusual circumstance in this region. There was a fine belt of cottonwood, ash, and button-wood along the creek-bed, but it was being rapidly used.

A few miles south of Cottonwood, at a most unexpected locality, a good pool (it could hardly be called a spring) of water was found. It appeared to be well known to those who were in the habit of passing over the road, as the signs indicated that it was a regular camping-ground. From the number of deer-tracks about the place, it is probably the only water-hole within miles to which they could safely venture. Pasturage was about the same as at Cottonwood, but the soil was more sandy and unpromising in character. Clumps of grama-grass grew between the chico (*Atriplex Nuttallii*) and creosote-plant, (*Larrea Mexicana.*) The only tree was the inevitable piñon, which occasionally, in the more favored spots, managed to survive.

Here the trail turned off to Camp Grant. At one or two points, in the distance of twenty-five miles to that post, water could be found sufficient for camping purposes. There was no lack of grass along the trai, and some timber, too, existed along it in the arroyos and on the adjacent foot-hills of Graham Peak. We however kept the road, which was through a country of the same character, to Eureka. The valley in which this is situated, without having a constant-flowing stream, appears to have enough of water to meet all the demands of a large herd. The ground is at several points quite boggy, indicating a ready means of obtaining more water than appears on the surface. In fact, it is a sort of drainage-basin for the neighboring hills. A strip of fertile soil exists above the ranch. Timber of good quality can be had in abundance within a few miles. Without having anything to make this an especially attractive location for a home, there is no doubt that it will yet be an important point in the stock-raising interests of the country.

Camp Grant, (altitude 4,753 feet,) twelve miles east of Eureka, is on the southern slope from Graham Peak, in a region far from attractive in its appearance, yet in reality promising all the essentials of a desirable location in Arizona. Wood, water, and grass is an expression suggestive to a frontiersman of plenty and comfort for man and beast; and these are all present in abundance at Camp Grant. Much of the winter-supply of

hay is from the grama-grass, which grows so abundantly on the hills at the foot of the peak. The proximity of Graham Peak, (10,516 feet high,) which is densely covered with forest-growth, and on which there is an immense precipitation of snow and rain, causes many springs and small streams to reach the edge of the plain on which Camp Grant stands.

Twenty miles across the country is the well-known "Hooker's Ranch," where, with abundant water and good grass, large droves of cattle are now thriving.

The timber on Graham Peak is simply magnificent. *Pinus ponderosa* (the yellow pine of the region) covers thousands of acres, and attains a height of 80 feet, constituting a most valuable lumber; *Abies Douglassi*, reaches 90 feet; *A. concolor*, 70 feet, and *A. Engelmanni*, 40 feet. The first two are of great importance as a source of lumber. Under the present demand for timber, it is not at all probable that the supply will be exhausted for many years. The oaks so common on the lower hills of the Sierra Blanca are not so abundant, and do not range higher on Graham Peak than 6,500 feet. Between the oak and pine belts the manzanita (*Arctostaphylos tomentosa*) grows rather abundantly. In some portions of the country the red berries of this shrub are utilized by the natives in making an acid drink. The northern or Gila slope of Graham Peak has a barren aspect, the timber apparently not reaching so low an altitude as on the southern. No actual observation (barometric) was taken to determine this fact, which may be only apparent, as the seeming greater elevation of the lowest limit of tree-growth may be due to the more rapid falling away of the land toward the river. Bunch-grass (*Festuca* and *Poa*) grows luxuriantly among the timber on the dry hills from 7,000 to 9,000 feet. In the moist valleys leading from the main peak toward the plain, rushes and sedges grow luxuriantly, and make probably thousands of acres of valuable forage during the summer months. I am aware of the general statement that plants of these classes have little or no value as forage, and was inclined to adopt this current teaching, until, in 1873, I saw in the San Luis Valley of Southern Colorado bands of stock living entirely on these and remaining as fat as loose stock could possibly be. I had never seen more magnificent cattle or sedges.

During the winter months there is a heavy snow-fall on the higher portions of this peak. In summer its thunder-storms are of a character we may well call terrific.

I have already given the altitude of Graham Peak as 10,516 feet. Hence it is heavily timbered to its very summit. This, however, may be a proper place to allude to a fact not popularly known, *i. e.*, the height to which trees continue growing on a mountain-side in the cordilleras of the western continent does not increase as we approach the equator from the forty-first parallel, where it is between 1,100 and 1,200 feet. Thus in Colorado the average highest limit of timber, as deduced from observations on six peaks, is 11,533 feet. On the summit of Sierra Blanca, in Arizona, between the thirty-third and thirty-fourth parallels of latitude, after gradually decreasing in size, the trees disappear entirely at an elevation of 11,100 feet. For a full discussion of this interesting question the reader is referred to an article by Dr. Engleman in Transactions of the Saint Louis Academy of Science for 1862, page 129.

From Camp Grant to Camp Bowie (sixty miles) the road lay over a "rolling" plain in all respects similar to that about Grant. A spur of the Pinaleño range gradually disappeared toward the southeast, in the direction of a similar one advancing from the Chiricahui range. This tendency to union of the two ranges left the country dotted over with low, disjointed mesas, which rose above the general level of the plain as islands do from the ocean. The soil was largely made up of detritus from the adjacent ranges, and was in itself fertile enough, but water could only be found (and that rather uncertainly) at two or three points along the road. Here and there dry arroyos ran from the hills to the plain, and indicated the force of the torrent that at some seasons must sweep through them. In all these arroyos we find *Baccharis cærulescens* growing vigorously, despite its want of water at that time. It is one of the most distinctly localized plants of the region, being seldom found except in some such peculiar spot, where it luxuriates between extremes of wet and dry soil.

At Camp Bowie, which is situated on a limestone formation, we found a remarkable change of flora. The dry hill-sides had still their mescal plants, but in addition there were found growing *Cevallia sinuata; Echites microsiphon*, an unusual form of that widely diffused and variable species, *Machoranthera canescens;* a remarkable variety of ferns, among which were *Adiantum capillas, Veneris Asplenerom,* and *Filix-foemina*, neither of which have hitherto been reported from Arizona. The *Echites* was found growing at the base of the Santa Rita Mountains, and here, too, on limestone rocks. It was found in no other location. Piñon pine and Emory's oak, neither of which grew more than 20 feet high, were the prevailing timber on the hills just higher than the post. The season for collecting the acorns of this oak was, in August, at its height, and the Indians found a ready market for all they could bring in. They are taken to Tucson, where they command a good price, being either roasted or eaten uncooked. The taste is not unpleasantly astringent. It is said they must be taken immediately after falling from the tree to obtain them in prime condition. A wild cherry (probably *Prunus demissa*) was found in the neighborhood of Bowie, attaining at the Chiricahui agency,

a few miles farther south, the proportions of a good-sized tree. The fruit was large, and far superior in flavor to that of any other wild cherry I have tasted elsewhere. In fact, it was quite equal to many of our commoner cultivated cherries. Strangely enough, from ignorance or some superstition, the Indians were not accustomed to use it.

The mescal of the natives appears to comprise two species of agave, *i. e.*, *Parryi* and *Palmeri*. The underground stem is baked in a pit, the exterior portion peeled off, and then used by the Apaches as a regular article of food. It is nutritious and palatable, but to one eating it for the first time is said to be slightly laxative. Is this property due to a principle identical with or resembling aloin? A fiber is obtained from the thick leaves that answers for the manufacture of cordage, the Apaches making it into lariats. The juice is boiled into sugar or sirup, or distilled into a whisky containing an enormous percentage of pure spirits. The stem, when dead and dry, is then, as the last use to which it can be put, laid over the rafters of the native houses to spread the mud upon. And it is a fact all travelers in that region should know, that in some of the driest portions of the country thirst may be quenched by sucking from the cut end of the mescal stem the saccharine fluid it has such an abundance of. The Indians, with the same object in view, peel away the outer harder covering and chew the pithy material in the heart of the stem. Either plan may prove serviceable in time of urgent need.

Looking down the cañon from Camp Bowie, a beautiful view may be had of a portion of the San Simeon Plains. In August, when the grass is dried up, it fails to impress one as it would in the early spring-months, when the hill-sides and plain are literally strewn with flowers. Enough of grama-grass grows in the neighborhood of the post to afford abundant pasturage for all the stock. As might be expected, the water is strongly impregnated with lime, and is hence a fruitful source of bowel disorders among new-comers. The post garden was quite productive, and gave a fair supply of vegetables, its limited size being the only trouble.

Crossing the spur of the Chiricahui range south of Camp Bowie, we came to the present location of the Chiricahui Apache agency. Going from the plain east toward the mountain, the grass becomes abundant, the vegetation more varied, and the hills are covered with a fair growth of pine and oak. It is, in a word, one of the most desirable cattle-ranges in Arizona, having in many respects the general character of the valley of the San Simeon, but with more and better pasture. Water is abundant enough for herding purposes, though it does not extend far out of the mountains into the plains during the dry season.

Along the edge of the creek-bed there is a fine growth of button-wood, oak, and the small variety of walnut. The large herd of cattle belonging to the agency, with the Indian ponies, in all numbering several hundred head of animals, were ranging at will about the immediate vicinity, all looking in good condition, and without perceptibly diminishing the pasturage.

Sulphur Spring, twenty-five miles west of this agency and fifteen east of the Dragoon Mountains, is likewise an important location, from its abundant supply of good grass. Before reaching it the road for miles lay through a dense growth of saccatone-grass, which was of infinitely less value than the shorter grama that fairly covered the ground at the springs. Without exception, this was the best location for this we had seen. Associated with it were a number of other species of scarcely less value. The water is warm, but sufficient for grazing purposes. Earlier in the season this would doubtless prove a most interesting botanical locality. *Goniphrona globosa* and *Pectis filipes* were blooming in great profusion on the hill near the house. The neighboring Dragoon Mountains are yet in possession of the Indians, but will some day offer desirable locations for stock-ranches. There are several fine springs in them. The grass within reach of them is nearly inexhaustible.

The upper crossing of the San Pedro is thirty miles south of west from Sulphur Spring. The road to it nearing the river lay through a dense growth of *Acacia constricta*, mesquite, and dwarfed pines. Quite a large number of cattle roam over the adjacent region. At this crossing there is little or nothing done in the way of agriculture, though a few miles below along the stream a mixed Mexican and American population has occupied the land. They have productive farms, and supply much of the barley and corn for the Territory. All the ordinary vegetables of the country grow well there. There are now several thousand acres under cultivation. The divide south of this is too dry to be of any use, except when cattle can be driven either to the Cienega or San Pedro for water from the hills. The soil is largely made up of sand and gravel detritus from the adjacent higher ground. Near the Cienega there is a most luxuriant growth of saccatone-grass on the flats, which, though of little value in itself, indicates that the soil is capable of producing more important crops. The prevailing vegetation on the hills is the ubiquitous creosote-plant. *Anemopsis Californica* and a *Sarcostemma* grow abundantly on the damp ground near the water. The location is a good one for a stock-ranch. I shall refer to this, the San Pedro and the Sonoita Valley, under the head of PREVAILING DISEASES.

South of the Cienega the Santa Rita Mountains rise *probably* 10,500 feet above the

sea. Tucson lies west of them; and east we have the headwaters of the Cienega. Davidson's Spring is on the road to the Sonoita, and twelve miles from the Cienega. Here there is found a good spring, and plenty of forage in the country near by.

Following to the south, we ascended first through a fine valley, with everywhere abundance of grama and bunch grasses. Lateral valleys, here and there connected with the main one and the hills between, besides being well covered with the above-named grasses, had oak, pine, and mesquite clumps, the whole combining into a landscape of more than usual attractiveness. In addition to this, a small stream ran through the valley, supplying enough of water for all purposes except irrigation.

The valley gradually narrows into a cañon, and then "heads out" on a ridge, which once crossed, we were again in the Cienega, but much nearer its head. We had in twenty miles reached a point the river takes a much greater distance to gain. Here a wide, beautiful view opened up before us; for miles, south, east, and west, the magnificent rolling plain spread out. It is, indeed, the promised land for stock-raising. Every foot of the surface was covered with grass. Toward the base of the Santa Rita beautiful clumps of Emory's oak and *Quercus confertiflora* were growing. They were just dense enough to afford a shade, and yet did not interfere with the growth of the grass. There was no undergrowth of bushes, so that the scene would fairly bear comparison with a park. Streams, with water warm but pure, from the mountain, were flowing down almost every ravine. Springs broke out from the ground frequently, and usually furnished a large volume of water. Higher up on the mountain-side *Pinus ponderosa*, *P. flexilis*, *P. chihuahuana*, and scrub-oaks were growing abundantly. The supply of lumber for Tucson comes from this mountain. It sold at $125 per thousand feet. The dwarf Sonora deer and the black-tail were ranging in great numbers over the hills. I have never seen them so abundant as in this region.

The same character of country extended past the now abandoned site of Camp Crittenden to within a few miles of the Sonora line.

The Sonoita Valley proper begins at Camp Crittenden, thence extending south. For fertility of soil it is unsurpassed in Arizona. At one ranch we saw about one hundred acres covered with corn that would equal any in Illinois. It stood on an average over 10 feet high, and was splendidly eared. What the soil was capable of doing had it been properly cultivated I do not know, but this field was literally overrun with the large sun-flower (*Helianthus petiolaris*) and other equally vile weeds. The sight of such a crop of weeds and corn on the same soil was certainly indicative of an abounding fertility, and naturally enough suggested the question as to how much heavier either would have been without the other. Potatoes of good quality were produced in the same soil, and gave an abundant yield. Watermelons, onions, and smaller vegetables grew luxuriantly. Bordering the stream was a tangled mass of vegetation so dense that a way had to be cut through it.

That this valley in no distant past supported a much larger population than at present is evident from the abandoned dwellings, some so old as to be falling from age. It is not unlikely that the incessant raids of the Apaches may have been the cause. The water-supply failing may possibly explain the desertion of the ranches *higher up the valley*.

The Sonoita Creek rises and sinks several times within twelve miles below old Camp Crittenden.

Camp Lowell is situated six miles north of Tucson, at an elevation of about 2,000 feet above the sea-level. A small stream flows by the post, supplying water enough for it and also allowing irrigation of some small fields. The valley of the Santa Cruz, in which Tucson is situated, has along the river a belt of fertile land, on which the Mexicans raise two crops annually, by sowing the barley and wheat in November and cutting it in May. Corn may be planted in the same ground in June and matured in October. It is worth noting, as indicative of the character of much of the soil of Arizona and New Mexico, that in some places the Mexicans and Indians have for year after year been using the same soil over and over again, removing through their crops the elements of plant-life without even the pretense of returning anything in fertilizers, and still reaping fair crops.

The portulaca and chenopodium, which grow on the lower grounds, have been resorted to as anti-scorbutics when other food of proper character could not be obtained. The giant cactus grows more abundantly on the southern slopes of the Santa Catalina, range to the north of the post, than in any other region we traversed. Its skeleton, after the softer material has decayed, is largely used to cover the houses preparatory to their receiving the final covering of earth, and the fruit used by the Indians either fresh or preserved, or is by fermentation transformed into an intoxicating beverage.

Returning, we followed much the same route that we have already given a detailed description of, until we reached the northern slope of the Sierra Blanca. Here we diverged, taking the road leading east to the Rio Grande, which we touched at Fort Craig. From our point of divergence to Coyote Springs, about forty miles, the country was emphatically of the character known as mesa-country. The road taking advantage of all the valleys, lower plains, and ravines to gain the easting, water existed at

intervals, and good grass (though late in the season) was always found. Bands of antelope were numerous. The higher hills had their share of piñon and cedar, though after leaving the immediate neighborhood of the Sierra Blanca we no longer saw trees that could be called timber.

It is hard to understand why so desirable a country should have been permitted to remain so long unoccupied, when less valuable regions have been settled in spite of the Indians. From Coyote Springs to Tulerosa the region was more mountainous, having a scarcity of water along the route. We could see that there was abundance of grass of the usual arid-region kind, but no plants were collected, owing to the lateness of the season. The slopes of the mountains were sparsely covered with a good-sized growth of pine and fir.

The description of the country from Albuquerque to Agua Azul would, from a botanical or an economic standpoint, answer so well for the region between Tulerosa and Fort Craig that it is unnecessary to enter any further into details than to state that water is even more scarce, the supply at the time of our trip being too small to prevent suffering of men and animals.

In the admirable report of the commissioners on "the irrigation of the San Joaquin, Tulare, and Sacramento Valleys of the State of California," two propositions are laid down; *i. e.*, "the average yearly rain-fall over the basin of the Great Valley is sufficient to insure good crops annually," and "with a proper system of controlling the waters of precipitation and delivering them to cultivated lands where needed, annual crops may be assured." To these carefully-considered statements we may add another from the same source: "In 1870–'71 the total rain-fall was about 6.8 inches; in 1871–'72, 10.3 inches; in 1872–'73, 7.2 inches. In the first and third years the crops were failures; in the second year the harvest was an abundant one." From this, then, it appears that a difference in the rain-fall of 3.5 inches in one year and 3.1 inches in another made all the difference between a total failure and a good crop. This is about the equivalent rain-fall of two or three average wet days. There are records of 15 inches of rain in a single day in India, and of as much in six hours at Catskill, N. Y. These, however, were exceptional cases. The above quotations were in strict reference to the great valley of California, and presuppose that the needed rain should be received in February, "when the grain is several inches high." I have introduced them to establish a unit of comparison for the portions of Arizona and New Mexico we have under consideration. For this purpose they are the best *available* data from which to reason.

From the above it would appear that the first point of inquiry is the rain-fall. Reliable statistics are as yet most meager, and at no point have observations extended over a period of more than four years. Hence I use the figures as but approximations to the truth. The most accurate report is probably from Santa Fé, N. Mex., where the mean result for the years 1872, 1873, and 1874 is a little over 13.05 inches a year, the rain-fall of 1874, however, more than equaling that of the two years previous combined, showing thus a great variation in the yearly means. To what this was due I have no data for determining.

The following observations from points near our line of march I glean from Smithsonian Contributions to Knowledge, No. 222, by Charles A. Schott, assistant United States Coast Survey. It was published in May, 1872, and represents the most reliable observations up to that date: Albuquerque, N. Mex., (and in the Rio Grande Valley,) has in spring a rain-fall of 0.83 inch; in summer, 4.35 inches; autumn, 2.04; winter, 0.90 inch; or 8.12 inches for the year; (Fort Wingate, in the same Territroy, has in spring 0.71; summer, 9.35, autumn, 2.99; winter, 0.90; or for the year a total of 13.95 inches; its proximity to the Zuñi Mountains probably having something to do with giving a result so near that of Santa Fé. Camp Goodwin, in the Gila Valley and in Arizona, has a spring rain-fall of 3.21 inches; for summer, 7.20; autumn, 10.52; winter, 11.85; or a mean annual of 32.78 inches. This excessive amount of rain is probably due to the location, being in a region of more than usual evaporation, and which is between Graham and Turnbull Peaks on the south and the Sierra Blanca on the northeast, with also peaks of lower altitude northwest of it, the aqueous vapor rising with the air from the heated plain and being cooled on the mountain-tops to below the point of saturation. Old Camp Grant, in the valley of the San Pedro, (one season,) had, in autumn, 6.43; winter, 3.23; or for the two seasons 9.66 inches. Camp Lowell, at Tucson, received in the summer of 1867 4.30 inches; Tubac, south of Tucson and near the Sonora line, has about 10 inches of rain during June, July, and August. We may, from personal knowledge of the country, assert that these estimates are probably *not far from the results* observations during a term of years would give.

The general average derived from these observations would be a little over 10 inches for the year; but as they were taken at points of more than usual rain-fall in the region, we must remember that further observations at the same points, combined with those from the more arid areas in the Colorado Basin, will somewhat reduce the average.

Hence, then, the application of the above data must be restricted to the immediate vicinity of the spots at which the observations were taken, and only used in the absence of observations more reliable, which will extend over a longer period. This

leads naturally to the probable effect a more dense growth of herbaceous vegetation or of trees would have in retarding the rapid escape of this surface-water. That most of it is actually wasted, is evident. The violence of its precipitation or the rapidity of its flow from the surface even at times destroys the sparse coating of vegetation that may exist. The first effect of a good sod would unquestionably be to retard the water in its flow, thus allowing more time for its percolation along the roots of the plants to a depth at which evaporation would be less rapid, and hence the moisture would be productive of greater results as the period of its operation was lengthened. The deeper roots of the trees would be even more efficient in conducting the water beyond reach of immediate evaporation. The effect upon the streams would be that, instead of a rush of waters, often increasing into a flood and carrying destruction before it, the average amount of water would be greater, more of it could be utilized, and a larger area irrigated. Doubtless, agriculture in early years in such a region would have its own peculiar difficulties, the trouble being to obtain the first real growth; this done, each succeeding year the task would be lighter. That it can be done is certain. The only question is, how long will it be before the necessities of our civilization compel the occupancy of a country where such labor is needed to reclaim the soil!

It should be remembered in this connection that the seeds of the nutritious native grasses, that now grow sparsely in that region, could be, by sowing and care, readily made to furnish a turf, whose interlacing of stem with stem and roots with roots would confer the needed protection upon the soil, giving besides, in their subsequent death and decay, the elements of a greater fertility and the promise of more lucrative crops. Facts from similar areas prove the possibility of this. Competent observers state that since the advent of the Mormons in Utah the waters of Great Salt Lake have risen 12 feet, and are still rising; that the waters throughout the entire Territory are rising.

Cultivation of trees where water exists should be encouraged. Beside the air of comfort they confer on a homestead, they can at slight expense often be made to afford shelter to stock and to ward off the sweeping blasts, which so frequently do such damage to the crops. Where the irrigating-ditches are carried, two or three rows of cottonwood trees on either side would probably thrive, involve little or no expense in cutting and planting, and in a very few years more than pay for themselves. There are, besides, thousands of acres now unoccupied, where at a small expense luxuriant groves of cottonwood and other trees could be made to grow, and confer in a few years a different aspect on the entire country. It is fairly a question of political economy as to whether, for the purposes of increasing our agricultural areas, it would not pay the nation to offer liberal encouragement to tree-culture in our great Southwest.

Taking the entire area along our line of march through New Mexico and Arizona into consideration, the diseases appear to group themselves thus: In New Mexico, diarrhoea, rheumatism, mild pneumonia, and typhoid fever are the prevailing diseases, having a small mortality. In Arizona, malaria is the chief source of disease, especially along the southern line, where it impresses itself on almost every other disease; dysentery and a mild typhoid fever are also not uncommon. Here the death-rate is probably somewhat larger than in New Mexico. In some portions of the Territory the notorious unhealthiness of the best situations has been so great as to deter settlers from remaining in the country. In the fall of 1874 in the San Pedro Valley the death-rate was unusually large, (if we may credit report,) and the proportion of sickness excessive. The Cienega is certainly anything but healthy; and the Sonoita Valley appears to be almost a plague-spot, so far as malaria is concerned. Camps Grant and Apache, though usually enjoying an immunity from intermittent fever, had each some cases in 1874. A glance, however, at the list of the diseases above given shows two things conclusively: first that the malarial cases may in almost all instances be prevented by judicious use of quinine, or cured, if they should occur, by the same agent alone or combined with iron; second, that the other diseases, not being common, and seldom giving a high death-rate, in reality offer no obstacle to settlement in that region, being, in fact, the very diseases with which we are most familiar east of the Mississippi River.

It should also be remembered that some of the most densely-populated States in the Union were not long since as bad, or even worse, in some portions than the worst region to which I have alluded, *i. e.*, the Sonoita Valley, and that drainage and removal of the exuberant living and the decaying vegetation would vastly improve the sanitary condition of these places. That the excessive heat does indispose to active exertion is certain; but this feeling must be distinguished from an exhaustion, and it is common to all tropical and subtropical regions alike. *Sun-stroke is almost, if not entirely, unknown.*

To sum up the above, the following statements are probably correct concerning those portions of Arizona and New Mexico through which we were moving during the past season: first, that the soil, particularly that resulting from decomposition of the volcanic and sedimentary rocks, possesses the elements requisite for vegetable growth, and will produce crops when water sufficient for irrigating purposes can be had; second, that almost all points accessible to water enough for herds can be utilized as grazing-ground; third, that the forests, though localized, contain timber enough for the wants of these

regions for many years; fourth, that large areas, now abandoned for want of water, can be cultivated by a system of tanks which, during the times of plenty, shall store the surplus water for future use during the critical growing times of the crops; fifth, that under the conjoined influences of agriculture and forest-culture the excessive waste of water in surface-drainage and in rapid evaporation will be lessened, thus procuring from the same rain-fall more lasting benefit; sixth, that the prevailing diseases are of less than usual fatality, and can, in many cases, be absolutely prevented or readily cured, and that these diseases will diminish in frequency and severity as the country is brought under cultivation.

The immigrant must not anticipate seeing an immense stretch of country everywhere alternating in beauty between greenswards, heavy forests, and abundance of water, like the familiar spots of the East. He must expect at present to find sterility and aridity impressing their hard lines on every feature of the landscape; but he must also remember that Utah, so large a portion of which is now covered with fertile farms, with vineyards and orchards laden with fruit, was only a few years ago almost as unpromising as either Arizona or New Mexico now is; that it is still within the memory of man that prophets of ill-omen predicted that California, now one of the granaries of the Union, could never furnish flour enough for her own use. We may fairly expect, under the demands of our increasing population, that these waste places will be redeemed and made tributary to our civilization. Labor, here as elsewhere, will bring its reward, but acres of waving, maturing crops will not come unearned.

The general botanical results of the year's work are about 9,000 specimens of plants, representing nearly 1,000 species. Of these, so far as at present known, there are eight new species. It is probable that further investigation will bring to light more new forms in the collection. There are also a large number of species hitherto poorly represented in the various herbaria, but of which the collection of the last year contains an abundant supply.

A good deal of attention has been bestowed upon the medicinal plants of the region, and an abundance of material secured to furnish analyses of the more important of them.

There now remains for me but the pleasant duty of expressing my indebtedness to the officers of the various posts at which we called during the season of 1874. We everywhere received courtesy and assistance, the more delightful because it was spontaneous and sincere on the part of those who tendered it.

I have the honor to be, very respectfully, your obedient servant,

J. T. ROTHROCK,
Acting Assistant Surgeon, U. S. A.

Lieut. GEORGE M. WHEELER,
Corps of Engineers, U. S. A.

APPENDIX H 2.

REPORT UPON THE AGRICULTURAL RESOURCES OF NORTHERN NEW MEXICO AND SOUTHERN COLORADO, WITH ANALYSES OF SOILS, PLANTS, ETC. BY DR. O. LOEW.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS
WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., April 22, 1875.

Although a great portion of these regions will be of little use for agricultural purposes, in consequence of the limited rain-fall, which hardly exceeds 12 inches a year, there are still quite a number of sections in which agricultural and pastoral pursuits can be carried on. These fertile tracts assume importance when we consider the eager demand for the products of the fields and pastures among the mining-settlements of the mountain-regions.

While the agricultural lands are almost exclusively along the streams which furnish water for the necessary irrigation, the pastoral lands occupy the mountain valleys at altitudes of from 7,000 to 10,000 feet. At lower elevations the grass gradually becomes poorer or is replaced by the dreary sage-brush and monotonous grease-wood, low woody bushes with but little foliage. In yet lower altitudes this vegetation disappears, the nude sand, covered occasionally with a few desert-plants, taking its place.

In Southern Colorado splendid pastoral lands are found in the Wet Mountains, where the great Wet Mountain Valley alone nourishes 20,000 head of cattle, and produces 1,200 tons of hay annually; also in the valleys of Sangre de Cristo Mountains, and their southern and most elevated extension, the Cerro Blanco, whence the Huerfano and Ute Creeks rise, the former sending its water through the Arkansas into the Mississippi, the latter through the Rio Trinchera into the Rio Grande. Other prominent pastoral

lands exist in the San Juan Mountains, Uncompahgre Mountains, in the main range, extending from Trinidad to Santa Fé, and in the great mountain regions between Abiquiu, Jemez, and Nacimiento; also, but to a less extent, in the Placer Mountains and about Mount Taylor.

The most prominent agricultural lands are the bottoms of the Arkansas, Rio Grande, and Pecos. Good, fertile lands of smaller extent occur along the Trinchera, Culebra, Costillo, Chama, Ojo Caliente, Santa Clara, Jemez, and Puerco Rivers, all tributaries of the Rio Grande; also, farther along, on the Huerfano, the Muddy, the Saint Charles, and the Animas streams, tributaries of the Arkansas, and on the Mora, Vermijo, and Ocaté, tributaries of the Canadian, and along some portions of the San Juan River and its tributaries.

THE BOTTOM OF THE ARKANSAS.

This river is flanked by belts of excellent land covered with a splendid vegetation as far as the river spreads its moisture through the soil, forming a most pleasing contrast with the barren, sandy plain above the valley proper. This valley has a width of a half to two miles, and is traversed by the Denver and Rio Grande Narrow-Gauge Railway from Pueblo to Cañon City, a distance of about forty miles. It is covered with a number of prosperous farms, valued, unimproved, at from $20 to $30 an acre. The town of Pueblo has constructed, at an immense cost, an irrigating-ditch twelve miles long, in order to render the barren plain, 30 to 40 feet above the river-level at South Pueblo, available to agriculture, and to enhance the value of the adjoining lands for farm purposes. A great number of trees also have been planted along little irrigating-ditches issuing from the large ditch.

In excursions up the valley of the Arkansas, I stopped for a few days at "Carlisle," a prosperous farm twenty miles above Pueblo. The fields, as a whole, were in splendid condition, as were the crops also, especially beans and corn. Potatoes,* I was informed, would not grow here. It is true, the vine reaches a splendid development, but the bulbs remain small or do not develop at all. A similar statement was made more than once in New Mexico the year previous, but was discredited at the time, on my being informed that the true cause of the difficulty was the careless treatment of the crop by the Mexicans. Careful inquiry, however, has convinced me of the truth of the statement. It is impossible to raise potatoes except in the higher altitudes, from 7,000 to 8,000 feet, as, for instance, in the Huerfano Park, where they grow very well. The reason appears to be that the evaporation from the leaves of the plant is increased by the dry air of these countries to such an extent that the sap is drawn chiefly to the upper and peripheral parts, thus developing a vigorous foliage with long stem and branches, while the bulbs cannot be developed even with irrigation. But why, it may be asked, do the roots of other edible vegetables, as the turnip, have an enormous development? A sufficient reason for this apparent contradiction to the above hypothesis may be found in the different organization and other proportions between the leaves and the body of the plant.

The proprietor of the farm at Carlisle also called my attention to what he termed "alkaline spots," referring to certain spots in his bean-field on which nothing would grow to any extent, the plants showing a poor development, and forming a remarkable contrast with the surrounding portions of the field. These so-called "alkaline spots" existed, also, in the corn-field, although in the proprietor's experience corn was not as largely affected by the peculiarities of such spots as the bean. Taking a lump of the earth and showing me the little white spots to which he referred, he remarked, "These are the obnoxious alkali." On examination, however, I found that they were nothing more than particles of gypsum, and explained to him the different mechanical conditions of the soil, which in patches is exceedingly clayey and baking, while generally it is of a normal porous character. The existence of these patches can easily be explained. The field was formerly—but how long since is not known—the bottom of the river-bed, and of course the current of the stream more or less effected a separation of the finer clayey particles and the coarser ones, as can easily be observed in any river; the finer particles will be deposited where the water is shallowest and the current slowest. At the same time, however, soil subjected to irrigation will always bake comparatively more easily than that not thus treated. Specimens of the productive and unproductive spots were collected and subjected to a mechanical analysis by elutriation, the result being as follows:

	Productive soil.	Unproductive spots.
Clay	11.2	40.7
Silt	25.7	30.3
Sand	63.1	29.0

* The potato here referred to is the Chilian, often, though erroneously, called the Irish potato. Chili being the country of its discovery, it should be called the Chilian potato.

A soil with 40 per cent. of clay bakes too much for fruit.

Three miles above Carlisle, Beaver Creek empties into the Arkansas River, which, at that point, has about double the volume at Pueblo, twenty miles below, where the supply of water is much depleted by large irrigating-ditches. The average yield of the farms is 40 bushels of corn, or 50 to 60 of wheat per acre. A specimen of soil from a fine corn-field near the farm of Carlisle, was analyzed, the result being as follows:

Potassa	0. 147
Soda	traces.
Lime	2. 53
Magnesia	0. 12
Oxide of iron and alumina	0. 62
Phosphoric acid	0. 061
Sulphuric acid, chlorine	traces.
Hygroscopic moisture	2. 79
Chemically-bound water and organic matter	3. 51
Insoluble in hydrochloric acid	89. 21

Twenty-five miles southwest of Pueblo is the Greenhorn range, which rise above the plain gradually to a height of 5,900 feet, where the mountains proper commence. Around the base of the mountains and between the foot-hills are fertile valleys, drained by a number of creeks and well grassed over. Ascending the mountains along the valley of Hardscrabble Creek, and passing the divide, we descend, on the southern slopes, into Wet Mountain Valley. On the route is Rosita, a comparatively new mining-settlement. About five years ago this valley was selected as a farming-settlement by one Mr. Wallston; a town was laid out and named Colfax before a single house had been erected; but the enterprise proved a failure, not only on account of night-frosts almost every month of the year, incident to the great altitude, but also from bad or injudicious management, the colonists being selected from among unsuccessful Chicago tradesmen, who were ignorant of farming.

The Wet Mountains on one side, and the Sangre del Cristo range on the other, not only inclose this valley, but also farther south and in lower altitudes the valleys of the Muddy and Huerfano, (Huerfano Park.) In the second and third are 250 ranches and farms, farming being done by irrigation from the Huerfano. Among the settlers are Americans and Mexicans. Mr. Moore, who settled here twelve years ago, informed me that he had 120 acres under cultivation, and raised 2,000 pounds of wheat to the acre. He cultivated, besides, corn, oats, barley, watermelons, and potatoes; beans and beets have not as yet been tried. The high price of potatoes—5½ cents a pound—was on account of but few places being able to produce them. The altitude of the Huerfano Park (6,600 feet) is such, that the dryness of the air does not exert much influence, the average temperature being lower. Corn brings 4 cents a pound; wheat 3 cents. The park itself contains but little grass, but there is good pasturage some miles off between the foot-hills of the mountains, where cattle and sheep are raised, the former to the extent of 12,000 head. There are numerous little creeks draining the slopes of both mountain-ranges, among them Turkey, William, Pass, and Jamero Creeks. Between May 15 and October 10 frosts rarely occur in the park.

Between the foot-hills of the mighty peaks of the Cerro Blanco are a number of fine valleys, among which is the valley of Ute Creek—a stream reaching San Luis Park at Fort Garland, and soon afterward emptying into the Sangre de Cristo Creek or Rio Trinchara, a tributary of the Rio Grande. The San Luis Valley in its southern portions is dry and sandy, excepting the bottoms of the penetrating streams, and is covered with sage-brush and grease-wood, *Artemisia tridentata*, *Sarcobalatus vernicularis*, *Aplopappus*.) The surgeon at Fort Garland, Dr. Moffat, called my attention to a so-called poison-weed, a small leguminous plant growing along the river-bottoms, and by many thought to be very injurious to cattle, numbers of ranchmen having left the San Luis Park on account of heavy losses in their herds. It being rather unusual to find poisonous plants among our western leguminosæ, I suspected a mistake, and attributed the poisonous result in question to *Aconitum napellus*, a decidedly poisonous plant growing here and there along the river-margins, and particularly where the altitudes are over 7,000 feet. But it had been repeatedly observed that the latter plant was never touched by cattle. The leguminous plant there called "poison-weed" was determined by the botanist of the expedition, Dr. Rothrock, as *Oxytropis Lamberti*. Dr. Vasey, botanist of the Agricultural Department, states that in California also bad effects are experienced from another leguminosa.

The San Luis Valley proper is about one hundred and forty miles long, and averages fifty-six miles in width, but only a small portion of this area can be irrigated. The southern part has an elevation of 6,700 feet, while the northern section is perhaps 300 to 400 feet higher. The water of the Rio Grande, where this river traverses the valley, is available at only a few places, being hemmed in chiefly by deep cañons. In the southern portion of this park is a moderate depression, into which empty a number of creeks. This depression is the so-called San Luis Lake, the last remnant of a former

great inland lake, whose margins may still be traced along the western and southern slopes of the Çerro Blanco. The southern extension of the park is traversed by the Culebra and Costilla Creeks, two streams carrying a considerable bulk of water, and sufficient for irrigating large areas. The soil is very good, as is shown by the following analysis of a specimen from the valley of the Culebra:

Potassa	0.113
Soda	0.025
Lime	0.702
Magnesia	0.030
Oxide of iron and alumina	7.032
Phosphoric acid	0.193
Hygroscopic water	5.310
Chemically-bound water and organic matter	6.080
Insoluble in hydrochloric acid	79.060

The average temperature of the four days of travel through San Luis Park (August 17 to 21) was, at sunrise, 50° F.; at 2 p. m., 82°; and at sunset, 63°. Some Mexican settlements have been established here within the last twenty-five or thirty years. It is an interesting fact, and one I have not seen stated in print, that a continuous migration of Mexicans from New Mexico to Colorado has set in since the former was annexed to the United States.

I did not visit the Taos and Conejos valleys. Our way led up the San Antonio Creek to the San Juan range, across a basaltic plain covered with but little grass. The sage-brush, so abundant on the eastern side of the Rio Grande upon the pebbly soil of the higher portions, has entirely disappeared from here. For long distances the San Antonio Creek is shut up in a basaltic cañon of an average depth of 45 feet, a cañon commencing a few miles west of the Mt. San Antonio, a round basalt cone at an altitude of 9,000 feet. This, of course, is unfavorable as a locality for farming purposes, but as the valleys of that altitude are covered with fine grass, it is well suited for stock-raising. There is excellent pine-timber in this portion of the San Juan range, but the altitude at which the pine begins usually to grow is here not the same, but about 600 feet higher on the northern slopes. Here are evidences of destructive forest-conflagrations, sometimes hundreds of acres being covered with fallen charred timber, which is a great obstacle to travel. In altitudes above 8,500 to 9,000 feet such burnt areas will be quickly grown over by quaking-aspen, these trees developing in such dense masses as to render one's progress almost impossible, many hours with the ax being required to advance a single mile. In altitudes lower than 8,000 feet, forests once burned down will re-appear but very slowly, and in many cases never again. This alarming fact is due to the dryness of the climate in summer, which prevents germination or kills the young germs.

Descending the southern slopes of the mountains, we reached Tierra Amarilla, a small and comparatively recent Mexican settlement amid the pine-woods. Two streams of moderate size traverse this region—the Brazos and the Nutritas—the former threading its winding course some distance above the town through a narrow cañon in quartzite 800 feet deep. Here the grandeur of the scenery is overwhelming and awe-inspiring. The altitude of Tierra Amarilla being so great, 7,900 feet, Indian corn cannot be raised, but wheat, rye, and oats succeed well. Here cattle find abundance of grass, but the snow-fall in these mountains being quite considerable, in winter they have to be driven into the lower valleys of the Rio Chama and Rio San Juan. Elk, beaver, and trout abound.

There are in the vicinity several other small Mexican settlements—Nutritas, Brazos, Los Puentes, Ensenada. The name Tierra Amarilla, or yellow earth, is derived from a yellow clay which colors the river-water after rain. Between Tierra Amarilla and Abiquiu, forty-seven miles south, and on the banks of the Chama, are some limited sections useful for agricultural purposes; also, some narrow strips along Cebolla and Cangelon Creeks. The country between the Cebolla and Chama is very irregular and cañoned. The Chama is wide, and carries a considerable bulk of water; at Abiquiu it measured 30 feet in width and 2 feet in depth. Above this town little land can be irrigated, the country being very broken and the river shut up in a cañon; but from Abiquiu to the junction of the river with the Rio Grande (nineteen miles) are bottom-lands that can be irrigated. Although the soil is a deep heavy sand and the surrounding country has a barren appearance, still there are a number of Mexican farms, with numerous fields. The soil is a good average one, the analysis of which resulted as follows:

Potassa	0.088
Soda	0.013
Lime	0.726
Magnesia	0.149
Oxide of iron and alumina	1.730

Sulphuric acid	traces.
Phosphoric acid	0.061
Hygroscopic water	1.790
Chemically bound water and organic matter	1.390
Insoluble in hydrochloric acid	93.30

The Rio de Chama has three affluents between its mouth and Abiquiu: the Bear Creek from the south, and El Rito and Ojo Caliente Creek from the north. The first and second are of little value, their bodies of water being too small for irrigating purposes; but it is different with the third, which furnishes water sufficient to irrigate the bottom-lands through which it runs. Fourteen miles above its mouth is an old Mexican settlement, the town of Ojo Caliente, so called from the hot springs near by, with splendid fields of corn and water-melons. About six miles below this town are the ruins of a Mexican village containing about twenty houses; the pasturage being poor in the vicinity, the inhabitants had gone to the mountains.

From Abiquiu south as far as Jemez, and west as far as Nacimiento, stretches an extended mountain region, the southern portions of which are called Jemez and the western Nacimiento Mountains. Here are the two Abiquiu Peaks and the Jemez Peak, about 11,000 feet in height. The numerous mountain-valleys are well grassed, and numerous herds of cattle and sheep roam therein. Springs and small mountain-streams are numerous. These valleys are surrounded by splendid forests of pine. In winter the stock has to be driven into lower altitudes, the snow being very considerable. Night-frosts occur here even in midsummer, rendering farming impossible. The scenery of this plateau is exceedingly charming, and if any region of the West deserves to be called "park," it is this one; indeed, it was proposed by some of our party, and not inappropriately, to designate the region "Paradise Mountains."

On a very small stream on the western slopes of the mountains in question is the settlement Nacimiento. To utilize more land than is at present available for agricultural purposes, an aqueduct is to be constructed from a neighboring tributary of the Guadaloupe River. If this is done, thousands of acres in the vicinity can be farmed. From Nacimiento southerly to the foot of Mount Taylor, and westerly to Cañon Bonito, the country—about five thousand square miles—has an extremely desolate and barren aspect, consisting, as it does, in either a sandy plain with a meager supply of grass and arroyos, or elevated mesas, covered with juniper and partially with piñon; the average elevation is about 5,900 feet. This region is traversed by the Rio Turreones, Rio Puerco, belonging to the Atlantic side of the divide, and the Cañon de Chaco, belonging to the Pacific side; these streams, however, rarely contain running water. There are also a number of springs, among which may be mentioned Ojo del Alto, Ojo de la Cueva, Ojo San José, Ojo de Tao, Ojo del Espiritu Santo, and Willow Springs. Sheep are occasionally driven over this locality to pick the little grass to be found, but at times the herds wander too far from the springs, or water-holes, and die of thirst. On one occasion we came across some forty skeletons of sheep along a single dry arroyo. Another fact observed here is worthy of mention on account of its bearing on the dryness of these regions, viz, the existence of deserted ant-hills here and there upon the isolated sandstone mesas of small extent. Here the ants construct their hills from much larger pebbles than do those in the Eastern States, the sweeping winds of this section easily blowing the small particles away and rendering firm structures necessary. Neither living nor dead ants were to be found, but legs and wings of inects that had served the ant for food were seen. Had the ants died in these hills, surely some of their horney tissues would have been left, as of the beetles. There is no doubt in my own mind that the ants had gone to the deeper valleys and cañons where some grass and consequently insects existed; the grass having died out on these mesas, bugs and beetles had taken their departure. This would seem to indicate increasing dryness of the climate of New Mexico, the inhabitants of which are convinced that it becomes drier and drier every year. "*El tiempo se pone mas seco cada año,*" (the weather grows drier every year,) sighs the Mexican.

They tell of springs and creeks that existed one hundred and some fifty years ago; indeed, even of some that have disappeared within the last fifteen years. Among these, a Mexican of Abiquiu mentioned the Rito Coyote, Rito Vallecito, and Rito Colorado de Abiquiu, all once existing in the mountains near Abiquiu. The provinces of Tiguex and Quivira, (the former on the Rio Puerco, the latter east of the Manzana Mountains,) described by the early Spanish visitors as fertile countries, are now barren. Ruins of former Indian towns are found twelve to eighteen miles away from any water, one discovered by Lieutenant Whipple being fifteen miles north of the Rio Mancos. There must certainly have been water in this section formerly. It seems to me not impossible that New Mexico, which was to a great part up to the Cretaceous and even partially up to the Tertiary, the bottom of the ocean, and was, toward the end of the Tertiary period, lifted up to a considerable altitude,* (the bottom of this Tertiary sea

* Most probably in connection with the enormous and unparalleled outbursts of trachytic and basaltic material, and the accompanying volcanic convulsions.

being now 5,000 to 6,000 feet above sea-level,) is involved in a slow, gradual sinking. Comparing the altitudes of good pastures and prospective forests with the barren lands full of ruins, and taking into consideration the fact that many of the ruins were left at least two hundred and others three hundred years ago, and, further, assuming that the air had the same degree of dryness then as now, (the contrary not being capable of proof from cosmical phenomena,) the sinking of the level is estimated at 50 feet in a century at the least. If this hypothesis is correct, in ten thousand years the ocean-waves will wash over the level of the plains of New Mexico. The atmosphere of New Mexico holding but little moisture, the absolute humidity going down at times as low as 1.3 grams per cubic meter, (a fifth to a sixth of the usual humidity in such latitudes,) less and less of it will be precipitated upon the mountains with the sinking of the level; therefore, the bulk of the springs and streams will be gradually diminished, and the latter run dry before they reach the plains or the base of the mountains. Unfortunately we have no barometric data from the early Spanish visitors, who regarded rather the religious subjugation of the Indian than scientific observation.

Along the northern rim of the Nacimiento desert, near the Mesa del Raton, I often observed, between the patches of cedar-bushes, considerable tracts of soil perfectly smooth, shining like polished tables, and without the slightest trace of vegetation. On examination the soil was found to be dry clay, which on mixing with water becomes very plastic and at once fit for the manufacture of pottery.

As interesting, it may be mentioned that amid the desert in question are valleys where farm-produce can be raised without irrigation, notwithstanding the absence of rain. This fact was demonstrated by Navajo Indians, who recently settled near the head of Cañon de Chaco, a little above the ruins of the ancient Aztec town, Pueblo Bonito, (named by Mexicans.) I saw, myself, the corn-fields and water-melon patches in splendid condition. A similar case is mentioned in Vol. III, Survey Reports, in connection with the Moquis farming in Eastern Arizona. I observed like cases at Agua Fria, five miles south of Santa Fé, and at Las Vegas, on the eastern slopes of the Rocky Mountain chain. The assertion of a writer in the Agricultural Report for 1868, that crops cannot be raised in New Mexico without irrigation, is, therefore, not altogether correct. Another writer, in speaking of the farming of the Zunis in Western New Mexico, supposes the section of country they occupy is favored with more rain than other portions. He writes: "Even around Zuni, where an ample supply of water can be obtained from the Zuni River, there are no acequias, the inhabitants relying on the rains to supply the necessary moisture. There is probably some peculiarity connected with the local atmospheric currents here, which collects the moisture or causes its separation and fall." To the author of this statement it appears a mystery how corn can be raised in a sandy barren valley like the Zuni, the explanation of which is that the Indians plant their corn about a foot deep, where the roots find a stratum of ascending humidity, which, however, on nearing the surface, rapidly is carried away by the dry air, making the development of seed near the surface impossible, and hence the limited growth of grass in juxtaposition to the splendid corn-fields. This practice of planting the seed so deep could not, of course, be carried out in other countries where moisture is plenty, as the seed or germ would rot before it succeeded in breaking through a stratum of soil a foot thick. The cause of the existence of the ascending humidity in the subsoil must doubtless be traced to the numerous mountain-chains everywhere traversing the country. Generally in the regions of New Mexico where farming succeeds without irrigation, water is reached at a moderate depth, which water is called *agua excavada*, a name given also to the head of Cañon Chaco.

The southern boundary of the Nacimiento desert is formed by Mount Taylor, 11,200 feet high, and, next to Peak Baldy, 12,000 feet, the highest mountain in New Mexico. This mountain and its foot-hills are well timbered and the occasional valleys well grassed. Several Mexican settlements are scattered through this section, the largest San Mateo. The southern slopes of Mount Taylor border another sandy plain having but little water—a plain extending about sixty miles to the southward of the slopes of the Madalena, Luera, and San Mateo Mountains. Not far from the southern base of Mount Taylor are several Indian pueblos, the largest of which are Acoma and Laguna, with 800 and 1,200 inhabitants. The Gallo Creek and Rito San José furnish the water for irrigating their fields and gardens.

The route from Laguna led northwesterly across the country to the Rio Puerco, and thence in a nearly straight line to Santa Aña on the Rio Jemez, on which are two other pueblos, Silla and Jemez. On crossing the Rio Puerco, about thirty-seven miles northeast of Laguna, are two Mexican settlements, San Ignacio and San Francisco. Some miles above these towns the river emerges from a cañon in which it is shut up for a considerable distance to the north; this river is frequently dry in summer. The irrigating-ditches are, of necessity, of considerable length, as the river is imbedded in a sort of gorge 14 to 16 feet deep. Its waters are very muddy, hence its name Pork River. This mud, however, consists principally of a plastic clay, and is unlike that of the Rio Grande, which is a fine silt with fertilizing properties. This latter river receives its muddy sediment partly from the Rio Chama and Jemez, and

partly from its own valley, becoming muddier the farther south we follow it. The entire country from Laguna to the Rio Puerco, thence to the Jemez, is of a poor character, consisting either of sandstone mesas, with here and there gypsum-beds, or of sandy undulating prairies with a scanty growth of grass upon which herds of sheep feed. The monotony of the barren landscape is relieved here and there by various flowers of beautiful colors—the so-called desert-plants, a collection of which was examined by Dr. Rothrock, who kindly furnishes the names of the species, which are as follows: *Bigelovia douglasii, Heliomeris multiflora, Mulchedium pulchellum, Melampodium cinereum, Gilia longiflora, Penathera pinnatifida, Abronia cycloptera, Townsendia strigosa, Heliotropium convolvulaceum.*

The Jemez Creek at Silla and Santa Aña does not carry a very large body of water in summer. I found the stream, if the three or four branches of the same bed be taken together, about 16 feet wide and half a foot deep. The two Indian pueblos here raise some corn in the valley of the stream. The valley itself is not wide and is hemmed in, particularly on the eastern side, by high mesas. Farther up, nine miles above Silla, is another Indian pueblo, Jemez, where the stream is considerably larger. This town has large tracts under cultivation and excellent grapes, peaches, and corn are raised. Following the stream about six miles farther up, we reach the union of the two branches of the Jemez Creek, Guadalupe and San Diego. Both run through great cañons, but along them are narrow strips of good tillable land. Some Mexican settlements occur on both these streams.

Taking an easterly course from Jemez and crossing a hilly country covered here and there with piñon and cedar, we reach the broad bottom of the Rio Grande near Peña Blanca and the Indian town Cochiti. Nothing remains to be said about the fertile Rio Grande Valley. This section was reported upon by the writer when with your expedition in 1873, and has also been made known by other visitors. It may be mentioned, however, that I visited, this season, a number of prosperous farms and was astonished at the luxuriant growth of the fruits. One of the finest vineyards near Bernalillo is in possession of Hon. S. B. Elkins, Delegate from New Mexico, to whose kindness I am indebted for a knowledge of many interesting facts relating to agriculture, mines, and ruins of New Mexico. The grapes of the Rio Grande Valley rival those of the world for richness of flavor and sugar. North of Peña Blanca the grapes are inferior, more acid, and of diminished flavor. From Cochiti up to San Ildefonso the river is shut up for a long distance in a cañon and but little land is available for cultivation, while from Ildefonso up to San Juan it is fringed with belts of good land with numerous Mexican and Indian towns. The river there has quite a number of affluents from the Santa Fé Mountains, while the valleys are tolerably well settled. It is a fact of no little interest that the Rio Grande, though slowly, is changing its bed wherever it runs through sandy soil. Houses have been deserted on account of danger from underwashing. Some of the inhabitants expressed fears even with regard to the future of Algodones and Albuquerque. A good deal of land on the east side of the river, several miles above Ildefonso, was quite recently washed away, while on the opposite margin, land was gained.

From Cochiti to Zandia the Rio Grande receives three affluents from the east side—the Santa Fé, Tuerto, and Galisteo Creeks. One writer, who evidently never saw these streams, says of them: "They afford strips of arable land varying in width from one to ten miles. But here also I think the amount might be increased by proper efforts and more extensive acequias." It is about proper time to expose such gross exaggerations; otherwise, taking them as truth, enterprising farmers may be induced to leave their homes for these regions. The truth is, these bottoms never reach a width of ten miles, while the streams have barely water enough for a single acequia.

With regard to the Santa Fé Creek, with which I am familiar almost its entire length, a peculiarity is, that about a half a mile below the city of Santa Fé it sinks, its bed becoming a dry sandy arroyo; but twelve miles farther down, in the vicinity of the basaltic mesa, which stretches at least forty square miles, it re-appears and again forms a stream of the same volume it had at Santa Fé. Near the little Mexican settlement Cieneguilla it enters a basaltic cañon 45 to 60 feet in depth, emerging at La Bajada. About five miles below Santa Fé, directly on the arroyo del Santa Fé Creek, is the Mexican town Agua Fria, (cold water,) rather a misnomer at present, since the water has to be brought in barrows a distance of two miles, there being none in the vicinity of the settlement. On inquiry, I was informed that about one hundred and fifty years ago the Santa Fé Creek was full of water, and that its margins were fringed with willows and alamos, whose shade kept the water cool; but the water sank gradually into the sand and the trees disappeared.

Wherever in the bed of the arroyo a hole of from 8 to 10 feet is dug water is struck, but the soil is too sandy and the wells soon fall in, the Mexicans not taking pains to construct them in a substantial manner. The fields of Indian corn in the vicinity were in good condition, thriving without irrigation, which, however, is resorted to whenever the Santa Fé Creek contains an unusually large bulk of water, which then reaches the heads of the acequias before it sinks. In my own opinion the sinking of

this stream is due not only to the gravelly character of the river-bed, but also, and much more, to the diminished water-supply from the mountains—a fact attributable partly to the disappearance of extensive forests once upon them, and partly to a diminished precipitation upon the mountain and lowering of the level of the whole region as above explained. Once during the last century the Rio Grande, near El Paso, behaved similarly after being dry a number of years; it disappeared above the town, and reappeared a number of miles below. Alexander von Humboldt hearing of this phenomenon, erroneously ascribed it to newly-formed subterranean cavities.

I may here notice another phenomenon characteristic of a dry climate. In exposed places where the soil is loose sand, it is gradually carried away, a fact nicely illustrated in the case of trees, whose roots are sometimes exposed to a depth of several feet, the trees appearing to stand on three or more legs. I observed them thus in the valley of the Rio Grande, near Algodones, and in the valley of the Chama, near the mouth of the Ojo Caliente Creek. Sand and dust winds are characteristic features of the plains of the southwest.

From Santa Fé our way was across the mountains to Las Vegas. Leaving the cañon del Santa Fé Creek, near the headwaters of this stream, we crossed over barren ridges covered with fragments of rocks, into the cañon of Macho Creek, a stream affording no bottom for agricultural pursuits, the cañon being too close upon the water-course. Near the junction of this creek with the Pecos River is the small Mexican village El Macho. The valley of the Pecos is of moderate width and well covered with fields of Indian corn, which is here raised in the highest altitudes in which it can be grown, about 7,000 feet. The country thence to Las Vegas is very broken and cañoned, tolerably well timbered, and contains some fine, but limited, grassy valleys. Near the head of the Tecolote Creek, large areas are covered with fallen timber, while the extensive fir-forests to the northward are in splendid condition; here these trees are thickly covered with a lichenous plant, *Usnea*, while the mosses *Hypnum* and *Racomitrium* are seen about the springs and rills. The bottom of the Gallinas Creek, running from those mountains to the southwest, is not wide; its available bottom-lands are occupied by Mexicans. About three miles north of Las Vegas this stream emerges from the narrow valley into the wide open plain, taking a southerly course. Considerable farming is done in the vicinity of Las Vegas. Mr. A. Green, an American, who settled here long since, complained of his failure with potatoes, while onions, cabbage, turnips, and melons grew exceedingly well. The cause of this failure he attributed to the "alkali" of the soil. Of how many mischievous things the "alkali" is accused in the West! The taste of gypsiferous water is attributed to the "alkali;" efflorescences, consisting of glauber salts, are called "alkali," and soil too clayey to produce crops is also accused of containing "alkali." I found it difficult to explain, in every instance, that the chief "alkali"—the potash—is the most important element of this soil! The following analysis shows that, while not to be classed as the richest, this soil is of good quality:

Mechanical condition:	
Clay, silt	35.3
Fine sand	52.6
Coarse sand	12.1
Chemical constituents:	
Potassa	0.161
Soda	0.020
Lime*	1.80
Magnesia	0.28
Alumina, oxide of iron	1.21
Phosphoric acid	0.03
Sulphuric acid	traces.
Hygroscopic water	2.37
Chemically-bound water and organic matter	5.40
Insoluble in hydrochloric acid	86.60

The potatoes used here are all brought from the Conejos Valley, a distance of nearly two hundred miles. I advised Mr. Green to plant a number of shade-trees in his potato-field to counteract the powerful rays of the sun, and thereby retard the growth of the foliage of the potato-plant, whereby bulbs might be formed on the roots. He promised to make the experiment.

Hay sells here from 1¼ to 2 cents a pound; corn at 2½ cents; potatoes at 6 to 8, and flour at 4 cents. Peaches, apples, and grapes are not raised. At times during dry years prices of provisions rise astonishingly. In 1865, flour was $20 a sack, of a hundred pounds, and at retail 25 cents a pound; corn $8 a fanega; beef 30 cents, and fresh pork 50 cents a pound, while a pound of bacon was held at $1. It is to be hoped that as the railroad is now almost to the boundaries of New Mexico these prices will not occur again.

* Present as carbonate.

From Las Vegas to Trinidad, along the eastern base of the main Rocky Mountain chain, are a number of settlements, the largest of which are Mora and Cimarron. The larger creeks are Cimarron and Vermijos, with tolerably wide valleys that can be irrigated and capable of supporting almost as large a population as the valleys of the Ocaté and Rayado. Trinidad, however, on the northern side of the Raton Mountains and in the valley of the Animas, is a very prosperous town, with a bright future. In the neighboring valley of the river are over 230,000 head of cattle and 500,000 head of sheep. The grazing is good, while the river carries a sufficient body of water to irrigate large areas. Besides agricultural facilities, there are beds of splendid gas-coal and good iron-ore in the vicinity.

A sample of the soil, from a short distance south of the town, proved to be of good quality; the result of its analysis is as follows:

Potassa	0.090
Lime	0.349
Magnesia	0.034
Alumina, oxide of iron	2.42
Phosphoric acid	0.071
Hygroscopic water	1.89
Chemically-bound water and organic matter	1.90
Insoluble in hydrochloric acid	92.24

ON THE CHEMICAL COMPOSITION OF GRASSES AND THE ASHES OF PLANTS.

The science of the geographical distribution of plants teaches us which species of grasses are adapted to certain altitudes, latitudes, climates, &c., but it does not reveal the varying values of these different grasses as material for food, nor does it show what chemical differences are produced under these varying circumstances. Recent investigations relating to the influence of atmospheric pressure upon germination show that an increased altitude does not correspond in all particulars to a higher latitude. In this connection, Mr. Bert has found that diminished pressure retards germination, a fact due to the diminished tension of the oxygen. If, however, in air of low pressure the amount of oxygen be artificially increased, germination is again normal. On the other hand, it was found that a pressure increased to about five atmospheres had an unfavorable effect on germination, due to the increased tension of the carbonic acid formed in the process of sprouting. The nature of the soil also has, in many cases, an important relation to the kind of grass upon it, and also to its chemical composition, decrease or increase of fibrous, saccharine, or extractive material. The more mineral substance and fiber a grass contains, the less of course is its value, the fiber being indigestible, and being mainly ballast to fill the intestines during the process of digestion and extraction of the nutritive matters of the grass; in regard to solubility, the latter substances are of three kinds, viz:

1. Substances soluble in water, as sugar, gum, tartrates, citrates, malates, amido componnds, as asparagin, &c.

2. Substances soluble in warm dilute hydrochloric acid, as starch, certain amido compounds, certain albuminates and glucosides; the starch and glucosides becoming transformed into sugar.

These two classes of substances will be digested easily in the gastric juice of the herbivorous animals, becoming soluble and absorbed by the system.

3. Substances soluble in a warm diluted potassa solution, comprising certain albuminate fats, and the incrusting substance of the cells. The substances of this last class are indigestible in the stomach, but become at least partially soluble by the pancreatic juice after leaving the stomach. This is due to the fact that the pancreatic juice has an alkaline reaction, while the gastric juice has an acid one.

An interesting question is that as to the effect of different grasses in the raising of stock. We know that the meat of Texan cattle by no means equals that of the cattle of the Eastern States; the former sells the more readily because it is the cheaper, and not by any means because it is the better. No doubt the composition of the grasses on which Texan cattle feed has a certain, though perhaps not an exclusive, effect to produce inferior meat. On the other hand, New Mexico grows the best wool in the United States, and it must be admitted that the nature of the grasses on which the New Mexican sheep feed has much to do with the superiority of the wool of that section. New Mexico, as a plateau averaging 5,000 feet in altitude, and penetrated by a large number of mountain-chains of an altitude of 10,000 feet and more, has, of course, quite a variety of climates, which are modified still more by the dry atmosphere of that country; hence the great variety of grasses met with. While the principal grasses of the 6,000 to 8,000 altitudes are the *gramma*, among which *Bouteloua fœna*, *B. oligos tachya*, and *B. hirsuta* hold prominent positions, *Bromus*, *Agrostis*, *Poa*, and *Festuca* are in altitudes of 9,000 to 10,000 feet, covering the meadows amid the gigantic forests of pine and fir. As regards lower altitudes than 6,000 feet, the growth of grass becomes more and more scanty. The sheep of New Mexico feed principally on the gramma

grasses, and wool-growing is indeed the best business that could be devised for the utilization of these prairies, the absence of water in most cases forbidding farming. Of late, wool-growing has reached great dimensions in New Mexico, and is still on the increase. In 1874 the wool brought by ox-teams to the termini of the railroads in Southern Colorado, Las Animas, and Grenada aggregated the enormous quantity of *one and a half million pounds.*

Three kinds of grasses were analyzed, viz:

1. *Festuca ovina*, (determined by Dr. Vasey,) from an altitude of 10,000 feet, Jemez Mountains, New Mexico. This grass covered chiefly the mountain-valleys of this region. I found it also on Sierra Blanca, Mount Taylor, and the Santa Fé range. It gave in air-dry state the following result, viz:

Water	12.3
Ash	5.4
Fiber	30.2
Fat	1.5
Aqueous extract, (of which 0.07 is sugar)	12.2
Sugar formed on digestion with dilute hydrochloric acid	10.8
Extracted by potassa and loss	27.6
	100.0

2. *Bouteloua olygostachya*, collected September 7, in the Abiquiu Mountains, at an altitude of 7,500 feet:

Water	12.0
Ash	7.8
Fiber	24.4
Fat	2.4
Aqueous extract, (0.08 sugar)	14.1
Sugar formed on digestion with dilute hydrochloric acid	22.2
Extracted by dilute potassa and loss	17.1
	100.0

3. *Bouteloua hirsuta*, the mesquite or buffalo-grass, collected near Las Vegas November 16, at an altitude of 6,500 feet. This grass, dried up and cured in the ground, had lost the green color and turned yellow; but, notwithstanding the exposure of this dead vegetation to atmospheric influences, it retained all its nutritive properties, as revealed by the analysis. The air-dry grass gave:

Water	13.0
Ash	6.5
Fiber	19.1
Fat	2.1
Aqueous extract, (0.09 sugar)	13.8
Sugar formed on digestion with dilute hydrochloric acid	26.3
Extracted by dilute potassa and loss	19.2
	100.0

The fiber obtained from the last species of grass was exceedingly fine and short, while that of the other two species was coarse and much thicker. On comparison, we find the mesquite is much richer in sugar-yielding material than are the others, and that the amount of fiber, or indigestible material, is smaller. This grass, as regards nutritive qualities, far excels the tall mountain-grasses, such as *Festuca* and *Bromus*, of either of which a much larger bulk has to be eaten by the animal to maintain the equilibrium of the system. Further, it appears also to surpass the grasses growing in less dry climates, as New Mexico.

Until now grasses have been analyzed only in Germany; hence, we can compare only with German grasses. On doing so we find the fiber of some of the best of the latter to be 21.7 per cent., or 2.6 per cent. higher than that of the mesquite grass. If we compare the amount of fiber in the three species analyzed as above, we find it increases with the altitude, or, better expressed, perhaps, with the increased relative humidity of the air. It would appear as though the dry climate retards the transmutation of the gum and sugar into cellulose, an observation which appears to be confirmed by the grasses of New Mexico, these being exceedingly rich in sugar.

With regard to the fat in the grasses, it hardly exceeds 3 per cent., although it is an important element in nutrition; subtracting the water, ash, and fiber from the total composition of the grasses, the relative proportion of nitrogenized to non-nitrogenized bodies is about 1 to 6.

It is also of interest, in connection with the organic composition of grasses, to know the composition of the inorganic constituents, the ashes of these plants, although our

knowledge of the respective functions of different constituents is thus far very limited. We are aware that the amount of potassa in these plants is in a certain ratio to the bulk of fiber and the soluble carbohydrates; we know, also, that without iron no reduction of carbonic acid and water can take place; further, that the phosphoric acid stands in close relation to the bulk of nitrogenized matter produced, and that without sulphates in the soil there is no production of albumen, but we have as yet no insight into the nature of these relations, and no satisfactory chemical explanation of the processes. With regard to some inorganic constituents of plants, we do not know even whether they are essential, for instance as regards magnesia and silica. The latter, as asserted by some experimenters, is entirely useless, but it must be borne in mind that the experiments upon which this assertion is founded were made with plants thriving in aqueous solutions in which all the other mineral constituents were present except silica. Whether such plants grown under such artificial circumstances, with an abundant accession of water, would stand an occasional drought as well as plants grown in soil, remains to be seen.

The question as to how a dry climate affects the nature and amount of the mineral constituents of the vegetation is interesting, but can be satisfactorily answered only after a great number of analyses. Some plants are exceedingly rich in mineral matter and dry up sometimes in the ground without losing their shape or color of leaves and flowers; the dead plants crumble to powder between the fingers, while from the intensity of the color of their flowers they appear as though in a living condition; *Zinnia anomala*—a fine yellow composite—may be mentioned. The same species of plant very often shows considerable difference in the composition of the ashes, according to the soil in which it was grown; therefore much precaution should be had in forming conclusions.

In the following table are the analyses of three German and two New Mexican grasses, from which it will be seen that great differences exist between the two classes as regards their composition.

	1	2	3	4	5
Potassa	6.41	8.53	9.32	43.3	38.45
Soda	....	Trace.	0.21	....	0.69
Lime	7.63	8.57	6.35	3.9	5.65
Magnesia	2.01	3.04	1.31	1.3	2.72
Oxide of iron	0.98	0.41	0.23	0.5	0.28
Phosphoric acid	1.50	2.01	2.15	6.3	10.60
Sulphuric acid	0.16	0.81	2.99	2.2	4.28
Silica	80.81	76.81	77.27	39.0	33.08
Chlorine	0.10	Traces	0.23	4.5	6.64
Total	99.60	100.18	100.16	101.0	102.39

No. 1.—Ashes of *Bouteloua fœna*, } New Mexico.
No. 2.—Ashes of *Bouteloua hirsuta*, }
No. 3.—Ashes of *Arnudo phragmites*, }
No. 4.—Ashes of *Alopecurus pratensis*, } Germany.
No. 5.—Ashes of *Poa pratensis*, }

Respectfully submitted.

O. LOEW,
Mineralogical Assistant.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

APPENDIX I 1.

ZOOLOGICAL REPORT, FIELD-SEASON OF 1874.

I. General Itinerary, by Acting Assistant Surgeon H. C. Yarrow, United States Army.
II. Notes, by H. W. Henshaw, ornithologist.
III. Notes, by C. E. Aiken, assistant.

I.—GENERAL ITINERARY, BY ACTING ASSISTANT SURGEON H. C. YARROW, UNITED STATES ARMY.

UNITED STATES ENGINEER OFFICE, GEOGRAPHICAL EXPLORATIONS AND SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., June 30, 1875.

SIR: In accordance with verbal instructions, I have the honor to submit the following report upon the operations and investigations in the zoological and botanical branch of the survey during the past year.

Since in previous years the collectors had always been attached to the topographical parties constantly in motion, which, from the nature of their labors, did not afford the same facilities for the proper study of areas zoologically considered, as would parties specially organized for zoological collecting, it was authorized and permitted that a special party should be dispatched under the charge of Dr. J. T. Rothrock, acting assistant surgeon, U. S. A., the botanist of the expedition, to New Mexico and Arizona, visiting, en route, specified points or localities where little or no zoological work had been done.

In addition to the collections made, observations by barometer for the determination of differences of altitude were obtained.

Accompanying Doctor Rothrock were Mr. H. W. Henshaw, as ornithologist, and Mr. James M. Rutter, as general assistant. This party was fitted out before leaving Washington, with every requisite for its work

Dr. Rothrock's instructions were that he should proceed from Washington to Santa Fé, from which place he was to proceed to Camp Bowie, Arizona, the southernmost point to be visited, passing in his journey the posts of Fort Wingate, New Mexico, Camps Apache and Grant, Arizona, returning via camps Lowell, Grant, Apache, Tulerosa, and Craig, to Santa Fé.

From the different posts which were to be considered as bases of supply, excursions were to be made to the neighboring forests and mountains to the eastward and westward, and in this manner a considerable area was to be covered in. It is gratifying to state that at every post the party experienced the greatest kindness from the officers, and every aid was tendered to enable them to prosecute successfully their arduous duties.

The results attained by this party exceed in numbers of specimens those of any previous year's work. It may be mentioned as an example of the character and value of the collections, that 9,000 botanical specimens of probably 1,000 species were secured, and of these 15 or 20 are new to science; 1,300 ornithological specimens, comprising skins, crania, sternæ, nests, eggs, &c., of which no less than 9 species are new to the fauna of the United States, besides hundreds of reptiles, fishes, and insects; in short, all branches of zoology and botany are well represented.

In addition, Dr. Rothrock obtained the altitudes of several important positions by means of barometrical readings.

In order that the route followed by his party may be more fully understood in detail, attention is invited to Appendix H 1. An extract from Mr. Henshaw's field-notes is also added, as having special reference to the ornithology of the regions traversed.

In view of certain paleontological work requiring larger intervals of time than could be spared with topographical parties, a second special party was organized and intrusted to my charge, in connection with Prof. E. D. Cope, paleontologist of the expedition. Mr. W. G. Shedd was assigned to it as general assistant, and Mr. R. J. Ainsworth as topographer and meteorological observer.

Instructions required us to proceed from Pueblo, Colo., to Taos, N. Mex., via Fort Garland, Colo., thence to San Ildefonso, N. Mex., on the Rio Grande, thence to Santa Fé and Algodones, returning to San Ildefonso, making this point the objective for the season's work, should circumstances justify. From San Ildefonso our course lay up the valley of the Chama to Abiquiu, thence to Tierra Amarilla, N. Mex., finally joining the main party at Pagosa Springs, Colo.

It may prove of interest to trace out this route and the results of the trip more in detail.

The character of the country from Pueblo to Fort Garland, over the Sangre de Cristo Pass, is so well known that no further description appears necessary, while the geological features will be treated of elsewhere. Little was noticed of special zoological importance until arriving in the vicinity of Badito, where representatives of ornithological and herpetological forms of life began to increase. In this neighborhood the following birds were noticed as tolerably abundant: the burrowing owl (*Speotyto cunicularia*,) the mountain mocking-bird, (*Oreoscoptes montanus*,) the blue-headed jay, (*Gymnokitta cyanocephala*,) besides the titmice and finches.

A few fish were taken at the creek, and quite a number of reptiles were secured, prominent among which were the "hog-nosed snake," (*Heterodon nasicus*,) and the horned toads, (*Phrynosoma douglassii* and *P. cornutum*.)

In this vicinity also, Professor Cope collected a number of valuable fossil marine invertebrata from the Cretaceous, and in addition a fair number of butterflies and other insects were secured.

Crossing the mountains at the Sangre de Cristo Pass, the military post of Fort Garland, Colo., was reached July 29, we having seen nothing along the road worthy of special mention. Every form of zoological life appeared scarce, with the exception of numerous butterflies of the commoner species. The absence of birds was especially noticeable, which was partly due to the lateness of the season. Among those seen were, notably, the broad-tailed hummer, (*Selasphorus platycercus*,) cow-birds, (*Molothrus pecoris*,) larks, a thrush, (*Harporhynchus crissalis*,) pipelo, &c.

On Ute Creek, near the post, a number of fine specimens of trout (*Salmo pleuriticus*) were obtained, and on the contiguous plain some few lizards were found, among them the six-lined lizard, (*Cnemidophorus sex-lineatus*,) and the *Holbrookia maculata.*

The line of march from Fort Garland was nearly due south to Taos, passing en route the flourishing settlements of Culebra, or "Snaketown," as it is commonly called, and Costilla, near which is the boundary-line between Colorado and New Mexico. South of Culebra, on the plains, were seen a few antelope, too wary, however, to be approached, and at different points numbers of prairie-dog villages were passed.

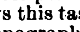
Instead of following the ordinary road, which turns westward from Culebra, one more to the eastward and seldom traveled was chosen, in order that the paleontologist might examine certain localities of geological interest. This road leads through an extremely fertile valley, bounded on the west by a mesa apparently of volcanic origin, over which we were obliged to pass to reach Costilla. A number of water-fowl were seen in the ponds of the valley, and hundreds of little squirrels (*Tamia quadrivittatus*) had their homes in the broken and irregular fragments of black basaltic lava which covered the hill-sides. A large fox was also seen in this neighborhood, and on the mesa road the first rattlesnake (*Crotalus confluentus*) was noticed.

Costilla was reached July 31, and some exceedingly valuable fish of new species secured in a small pond near the town. Time did not admit of any stay at this point, and the march was continued to the southward, passing the villages of Lama, Colorado, and San Cristobal and Rito Honda, reaching Taos August 3.

In advancing to the south the reptile fauna increased, and many valuable specimens were added to the collection, among them the collared lizard, (*Crotaphytus collaris*,) Marcy's garter-snake, (*Entænia marciana*,) and *E. radix*, while the *Phrynosoma* were noticeable in large numbers. Birds were very scarce, only a few horned larks (*Ermophila cornuta*) and ravens (*Corvus americanus*) being seen.

In the vicinity of Taos a stay of several days was made. Some little difficulty was here experienced in the selection of a camp, as the only available point affording pasture and water for the animals was very near to the Indian pueblo, called San Fernando de Taos. However, through the friendly offices of Mr. Müller, who deals largely with these Indians, we were finally permitted to select a desirable spot not far from the town. At no place, during the entire trip, were more valuable results attained than here. The day following our arrival, Mr. Ainsworth, the topographer of the party, was dispatched on a side-trip to Laguna Negra, or Black Lake, erroneously marked as Elk Lake on most of the maps. He was directed to ascend the highest peak near the lake and fix its position accurately by triangulation. Within two days this task was accomplished, and the remainder of his time was spent in gathering topographical details in the Taos Creek basin. At the same time the other members of the party were not idle. Professor Cope, assisted by Mr. Shedd, made frequent excursions to the hills and mountains in the vicinity, examining the Pliocene deposits of fossils, and many interesting, if not new, species were discovered. These deposits are familiarly known as the "Santa Fé marls," and are said to extend from the northward of Taos to at least fifty miles south of Santa Fé. Particular attention was paid by myself to a study of the peculiarities of the Taos Indians, their customs, habits, language, and habitations.

A vocabulary of useful words was secured, and many stone implements, supposed to be extremely old, were obtained, although apparently much valued as relics, the Indians stating that they have been handed down from generation to generation, and were made, as they believe, or at least imagine, during the time of Moctezuma.

So much has already been written in regard to the construction of the Pueblo dwellings that a repetition is unnecessary; but it may be mentioned that this village is typical of the better class of houses used by these interesting aborigines. We were surprised to find that in this pueblo, in lieu of a single estufa or council-chamber only, as is usual in other pueblos, each headman had a private one of his own, there being five in all. For a small sum of money we were permitted to view the one appertaining to the capitan de la guerra or war-chief of the tribe. It was found to be a large circular chamber under ground, the entrance being through a small trap-door on top, surrounded by a circular stockade, containing numerous antlers of deer, and having a narrow opening which could readily be defended by a single warrior. Descending to the chamber by a ladder, it was found probably 25 or 30 feet in diameter, arched above, and about 20 feet high; around the wall, at a height of 2 feet from the ground, was a hard earthen bench. On the floor in the center was an oblong pit, 2 feet deep and nearly 3 feet long. In this, it is said, the sacred fire is kept burning, and we were shown some live embers beneath the ashes. Behind the fire-pit is a sort of altar constructed of clay, in shape similar to the accompanying figure  ; the use of this it was impossible to ascertain. From a peculiarly sweet aromatic odor, which seemed to fill the atmosphere of the room, we inferred that probably in their rites sweet-smelling grasses or wood are used as incense. The war-chief informed us that it should be considered a great favor to have been permitted to view the interior of this estufa, as such a favor was seldom shown to an American, and never to Mexicans.

The government of these Indians, who appear to be ruled by no single individual, is

somewhat interesting. The cacique or high priest is the oracle and spiritual ruler, having the power to punish for irreligious acts and solemnize marriage ceremonies; in fact his consent must first be obtained before lovers may be betrothed. In the temporal affairs of the people he seems to be clothed with no authority. It is pleasing to note the great respect and reverence always paid to these aged men by the people; and a singular custom among them is that of drawing lots by the young men of the tribe to determine who shall support and take care of the cacique each year, and the successful competitor is deemed very fortunate.

The governor or alcalde of the village is in reality the ruler in all temporal affairs; he orders work, regulates the hours of labor, and in short performs all the functions of a chief magistrate. Unlike the cacique who holds his office for life, the alcalde is elected yearly. The emblem of his authority is a cane, which serves the double purpose of a writ when offenders are to be summoned before the bar of justice, and as a weapon to inflict such punishment as may be ordained.

The capitan de la guerra or war-chief holds his office by hereditary right, is responsible for the defense of the town in time of war, and leads the fighting portion of the population. He seems to exercise the right of supervision over the common pasture-field or "vega," and likewise claims the ownership of the hunting-grounds near the village. There are also several minor officials who act as constables and police, called alguazils.

Although these people are ostensibly Roman Catholics, there is no possible doubt but they are sun-worshippers, as each night and morning the greater part of them are to be seen on their house-tops chanting hymns of praise to this orb as he departs and re-appears. These hymns are inexpressibly sad and mournful, though beautiful and melodious, and similar in character to the droning song in a minor key of the negro; the words appear to be a succession of monosyllables, with frequent repetition. In the event of any occurrence of interest to the people, a public crier announces it from a house-top. We had an instance of this in our own case, as before we were permitted to encamp near the village a council was held to decide whether to treat us as friends or enemies. The decision being in our favor, the fact was publicly made known in the manner indicated.

These people seem to be particularly fond of having near their houses birds of different kinds, and a number of hawks and eagles were observed. The latter bird is looked upon as having a sacred connection with Montezuma.

The character of the Pueblo Indian is singularly at variance with that of the other tribes of New Mexico, being affectionate and childlike, innocent in manner and very honest, exhibiting none of that brutal and ferocious element common to most of the nomadic aborigines. These Indians are essentially a pastoral and agricultural people, tilling the soil with energy and industry. They claim a patch of land covering a radius of three miles square from the center of their town, and this portion of the Taos Valley is most fertile, and a veritable garden-spot. On all sides were seen fields of corn, wheat, oats, and barley, interspersed with large numbers of fruit-trees.

Mr. Miller stated that he annually purchases of the Indians about 6,000 bushels of fine wheat. They claim that they desire nothing from the General Government but protection against squatters on their lands, and appear to be abundantly able to take care of themselves. It was particularly pleasing to note the great degree of affection manifested by parents for their children, and also that they do not make beasts of burden of their women, as do the wild Indian tribes of the plains and mountains. Their laws in regard to thieving, adultery, and other crimes are severe, and offenders after trial are punished with commensurate severity. A stay of several days in the vicinity resulted in securing many zoölogical specimens, including several rare humming-birds, fishes, reptiles, and insects. A valuable mammal was found here, Baird's hare, (*Lepus bairdi*,) which had previously been observed only in the Wind River Range of Wyoming. This was a most interesting discovery, especially as regards geographical distribution, and it is curious that the species has not been discovered before in the southern territory.

At this place a first acquaintance was made with the "Penitentés," a powerful organization of religious fanatics, whose societies' ramifications extend to every settlement throughout New Mexico. The object of this secret society does not appear to be fully understood, but self-punishment for sins committed during the year is inflicted during the lenten season. At this time it is customary for the members to meet together, and after prayers and chanting, a procession is formed, which marches through the town. The different individuals who are selected as scape-goats on this occasion are stripped nearly naked and carry enormous crosses made of heavy beams of wood; others carry whips made of fibers of Spanish bayonet and soap-root, with which they flagellate themselves and others until their backs are covered with gory welts. Some of the most energetic of these self-made martyrs lie down in front of the procession and permit the others to walk over them; and the greater the suffering the more their religious fervor increases. This curious performance lasts for several days at a time, and is extremely disgusting to all sensible people. The priests of the Catholic Church have endeavored

in vain to break up this organization, but without success, as their numbers are constantly increasing. At Taos, where we first noticed them, one of their number had died, and the branch to which he had belonged sat up with the body all night, singing and howling.

They have meeting-houses of their own in which the profane are not permitted to enter, and these houses are, as a rule, far superior to their regular churches. It is a custom with them while traveling to make heaps of stones, with a cross on top, alongside the road at different points, and each member as he passes adds one to the pile. This is a peculiar feature to be seen upon all the roads of New Mexico, the natural inference being that these heaps marked the resting-places of the dead who had perished while traveling over the roads. The following notes, furnished by an old resident of New Mexico, relative to the organization, &c., of the order, are given below:

"Seems to be composed of lodges, each of which is independent of the other; no central power or authority, or if they do have, not extending above a limited section of country. A few of the towns have a lodge-room, or house, isolated, for the purpose of greater secrecy. The ceremony of bearing the cross and whipping in public takes place only during "Semana Santa," or holy week.

"Punishment is of two kinds, self-imposed and that imposed by the lodge, for real or imaginary sins; immunity from punishment can be purchased.

"Flourishes in the hill regions when the church-services are infrequent.

"Has not been countenanced by the recent representatives of the church, though in former years was not only countenanced but encouraged, and the churches were made the theater of the most severe whippings.

"Not unusual for one of the devotees to prostrate himself at the steps of the church so that all who enter must step on his body.

"In the mountain country, when the last week in Lent comes early in the year, the road to Calvary—a wide cross placed in the field, from a half to a mile from their lodge—is through deep snow, yet the journey is performed naked, their faces painted or daubed to prevent recognition.

"That the order is spreading under the opposition of the church is partly proven by the new Mounts of Calvary that have been erected during the past five years.

"These devotees frequently perish from their self-inflicted wounds, and it is imagined that a sure salvation is thus effected. The burials of any of their order always take place at night. There is hardly a reasonable doubt but that the ceremonies of the penitents have been transmitted from generation to generation from the flagellants of ancient times, and have been introduced from Old Mexico, at the time when they were encouraged by the priests."

Concluding the work at Taos, we left August 9 for L'Embuda, taking, instead of the old road over the United States mountains, the new one constructed in 1873 by Lieutenants Ruffner and Morrison, through the cañon of the Rio Grande, which not only shortens the distance very materially, but is better fitted for wagon-travel, the ascents and descents being less steep. The cañon road proper commences at a small settlement called Senegia and ends within two or three miles of L'Embuda, but will, it is expected, in time be completed to La Joya.

On the road few birds were seen, with the exception of ravens and jays, but in the rocks skirting the road many small mammals and lizards were noticed, and some few snakes were secured. At L'Embuda we tarried but a single night, pushing on the next day for Los Leuceuros or Plaza del Alcalde. The road lay through the Cañon de Cito, over a mesa to the eastward of our place of destination. We found this road for a short distance almost impracticable for our wagon, and were obliged to unload our supplies and pack them over a very steep ascent. This road, which is used to a considerable extent in the dry season, is in winter and spring the bed of a raging torrent, and to avoid it Lieutenant Ruffner proposes to finish his Rio Grande road to La Joya, as already mentioned. Near this latter place commences the most fertile part of the Rio Grande bottom, much of which showed evidences of thrifty cultivation; in fact, from this point to San Ildefonso, the greater portion of the land is susceptible of cultivation, water alone being needed.

Plaza del Alcalde was next reached, from whence a visit to the neighboring Indian pueblo of San Juan was made. This town differs materially from the Taos town, being built around a hollow square, the buildings rising two stories in height, instead of five or seven. In the vicinity, the Indians own most of the fertile lands near the river, and raise excellent corn and wheat, and, besides, a great quantity of fruit; peaches, apples, and watermelons predominating. At this season of the year they abandon their villages and erect temporary structures in their fields, in which they live, to watch over their crops and protect them from unscrupulous trespassers. From the alcalde of the previous year an interesting vocabulary was obtained. It may be interesting in this connection to mention the Indian method here witnessed of thrashing out grain. A suitable piece of firm ground is selected, perhaps 20 feet in diameter, and is carefully cleared of stones and gravel, water is then poured on it from time to time,

and a herd of goats is driven round and round until the surface is as firmly packed as possible; a circle of posts is then driven into the ground, and the whole is inclosed with ropes, on which are hung old bags or rags. Into the inclosure ten or fifteen mares are introduced and driven around in a circle, the straw containing the grain having previously been spread out. In a very short time the grain is beaten out by their hoofs and is gathered into a heap, being afterward winnowed from the chaff when a sufficiently strong wind will admit of it. These thrashing-floors are called by the New Mexicans "era."

Left Plaza del Alcalde August 14 for San Ildefonso, passing *en route* several small settlements. At Santa Cruz, left the main road and struck off to the right, passing more settlements and a curiously isolated hill of volcanic origin. Saw very few birds on the road; but snakes and lizards were very abundant. After leaving the hill to the right we had our first view of the "bad lands" proper of San Ildefonso, crossed the Rio Grande, and camped in a small grove on the river near the Indian meadow.

Professor Cope, who had preceded us, arrived during the evening, and reported valuable discoveries of fossils in our immediate vicinity. At this point the work of paleontological investigation commenced in good earnest. The bad lands of the neighborhood lie northeast from the village, some five or six miles distant, and extend over a considerable area. The different deposits seem to lie in strata of several colors, the violet-green one affording most of the specimens.

It is not necessary to recapitulate in this place the various interesting discoveries made here, as it has already been done by Professor Cope in his report. A great many specimens of fish were secured from the Rio Grande and adjoining pools, (many of them new to science,) as well as large numbers of butterflies, beetles, and other insects, and reptiles were especially numerous, particularly *E. marciana* and *E. ornata*. A few mammals were taken, and humming-birds also. At this point we found undoubted evidence of the occurrence of the "Gila monster," (*Helo derma suspectum*,) although, owing to the negligence of one of our men, a very fine individual was permitted to escape.

Much attention was paid here, as at Taos, to the habits, &c., of the Indians, and a vocabulary was obtained, as well as articles of clothing, pottery, and stone implements. An ancient pueblo, situated on a mesa to the westward of the town, was visited, and excavations made to discover crania and skeletons, but without success. Having received information of the existence of caves in the curious volcanic hill already alluded to, a visit was made, but nothing of interest was developed. Three caves were found, two of which had probably been excavated by persons digging for precious metals, and the other apparently was the vent-hole of an extinct volcano. The entrance to the latter is situated on the eastern side of the hill, probably 2,000 or 3,000 feet above the surrounding plain, and is a semicircular opening 10 feet high and 12 or 15 broad; it extends as a converging tunnel some 60 feet within the hill, descending by a slow gradient, the opening being finally closed by masses of stone and earth. It is said by the Indians to have been an ancient mine, but this statement is considered doubtful. It is to be regretted that time and limited means would not admit of a careful excavation. This hill appears to be formed entirely of basaltic lava, which fact would lead to the supposition that no precious metals could have been found.

The Indians of this neighborhood were exceedingly friendly and generous, and our somewhat limited larder received many valuable additions in the shape of green corn, watermelons, and other edibles.

While in the vicinity of San Ildefonso, Mr. Ainsworth, topographer, was engaged in the surrounding country, paying particular attention to the courses of the rivers Nambe, Tesuque, and Rio Grande, as well as of a number of smaller streams. In addition, the two roads leading to Santa Fé were both carefully meandered and measured.

From our camp in this locality, Professor Cope and myself proceeded to Santa Fé, and through the kindness of Gen. Irvin J. Gregg, Eighth United States Cavalry, an arrangement was made by which Professor Cope could pay a visit to Algadones, some forty-five miles distant, for the purpose of viewing certain fossil remains. Nothing of sufficient value, however, was found to justify our moving camp from San Ildefonso to that place.

At Santa Fé we received every possible kindness from all the officers stationed there, as well as from citizens, and after securing a supply of rations a return to camp was made.

The duration of our stay at San Ildefonso lasted until August 30, when we started for Abiquiu, in the valley of the Chama, passing, *en route*, the Indian pueblo of Santa Clara and the towns of Chama and Cuchilla, arriving at Abiquiu September 1. At this point a careful investigation was instituted to discover some beds of vertebrate fossils said to exist in the vicinity of Abiquiu Peak, but none were found.

Having learned of the existence of a most interesting deposit in the vicinity of Gallinas Creek, Mr. Shedd was dispatched to the town of El Rito to procure guides, with orders to join the party at Tierra Amarilla. Some interesting fish were found at Abiquiu, but birds and insects were very scarce. However, a most interesting discovery

was made here of an ancient pueblo and burial-ground in the valley of the Rio Chama, about three miles east of Abiquiu, and had been built on the top of a mesa, or table-land, rising probably 100 or 150 feet above the level of the river. This mesa lies at the foot of the Jemez range of mountains, and has the appearance of a high foot-hill from the valley; seen from above, it is simply a promontory of land in the shape of a trapezoid, or frustrum of a cone. At its base in each side were the only means of approach—two narrow, steep cañons, worn away by the streams of water from the mountains above. In case of war, these approaches could have been defended against thousands by a dozen resolute men with no better weapons than rocks and stones. The front of the mesa is a sheer precipice, allowing of no ingress to the town in that direction, and it would appear that the builders of it chose this spot with a considerable degree of sagacity, and with a view to a good defensive position, although we were unable to determine where, in case of a protracted siege, the inhabitants could have obtained water. A glance at the accompanying wood-cut will, perhaps, enable the

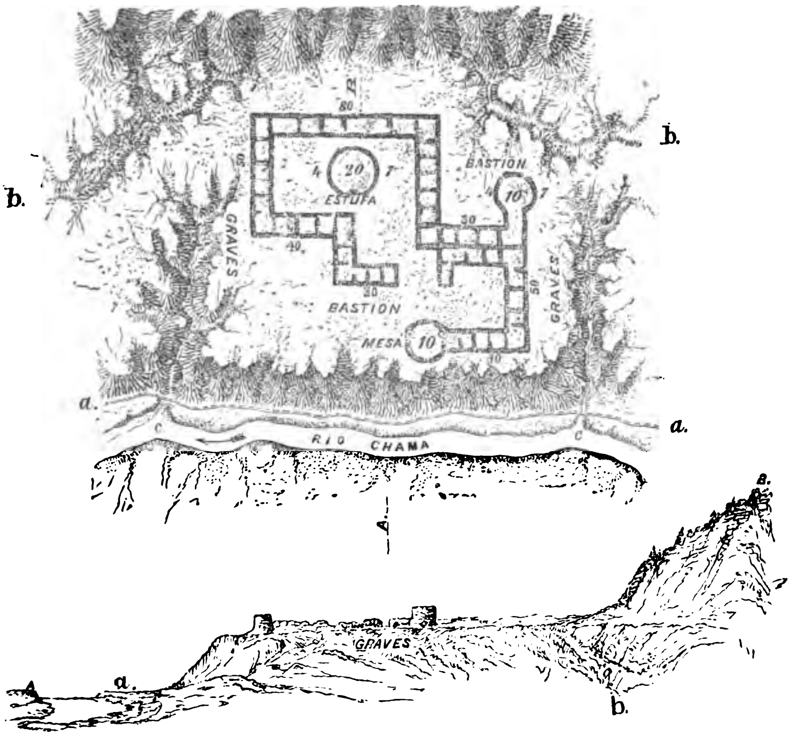


Diagram showing ruins in valley of the Rio Chama, near Abiquiu, N. Mex.

reader to better understand exactly the position of the mesa, village, and surroundings. The Rio Chama flows through the valley at the foot of the mesa, as represented in the cut, the road, *aa*, running alongside of it. The two cañons or approaches to the town are marked *bb*, and *cc* are two arroyos or ditches, in the sides of which graves were found. These ditches have been also formed in a similar manner to the cañons, but subsequent to the occupation of the village. It will be seen from the engraving that the town was built in the shape of a double L, having an open area, or court-yard, on both sides, and with bastions or towers at the corners, one defending the western cañon-approach, and the other the only entrance to the town. The front wall was 40 feet in length; the side wall, 50 feet; first rear wall, 30 feet; a prolongation of this, 40 feet; second rear wall, 80 feet; eastern side wall, 50 feet; the bastions being 10 feet in diameter; the estufa, or council-chamber, 20 feet. These walls had been built double, as is represented, and the dwellings were between, divided up into spaces about 10 feet square. Upon the supposition that each of the spaces were occupied by one family consisting of, say, five individuals, and that the structure was two stories in height, we may imagine the population of this town to have been in the neighborhood of 250. If the houses consisted of five stories, like some of the pueblo villages of the present day,

the population was doubtless much greater. The stone composing the walls are black basaltic lava, and have probably been brought from a considerable distance, as we were unable to discover any large deposit of this material in the vicinity. At the present time these walls are but 18 inches in height, and are gradually crumbling down, but enough *débris* is scattered about to show that an enormous quantity of the stone was used in the construction.

Interspersed with the stones are found great quantities of broken pottery, exhibiting the same peculiarities of markings and colorations as the fragments found in other ancient dwelling-places in this part of New Mexico, for examples of which the reader is referred to the report of Lieut. Jas. H. Simpson, of the Corps of Topographical Engineers, entitled, "Journal of a Military Reconnaissance from Santa Fé, N. Mex., to the Navajo Country," published in 1852 by Lippincott Grambo & Co., in Philadelphia. These illustrations are faithful representations of just such specimens of pottery as we have now in our collection from this village. In addition to the fragments of pottery, we found chips of black obsidian, of red porphyry, and carnelian, white and red; but not a bead, an arrow, a lance-head, nor an ax-head of stone or metal rewarded our long and eager search, which may perhaps be accounted for from the fact that the present Pueblo Indians have a great degree of regard and veneration for ancient stone implements of all kinds, and treasure them with great care.

The "estufa," or council-chamber, was carefully examined, and appeared to have been similar in its character to the ones at present used in modern pueblos. These chambers are formed by digging in the ground a circular pit from 10 to 20 feet in depth; a wall, in some cases of 2 or 3 feet in height, is built around the rim of the hole, and on this branches of trees or beams of wood are laid, forming a roof, which is covered with brush, and earth packed firmly on top. At the pueblo of Taos each headman has an estufa of his own, but in this and other village visited only one appears to have been in use.

After carefully examining the remains of the village, we set out in search of the graves, having been informed by Padre Salazar, the village priest of Abiquiu, that we would probably find some skeletons near the walls of the town, he having received his information from some sheep-herders who had seen bones in the arroyos while wandering over the mesa. We could hardly credit the statement, as it is well known that Indians, as a rule, are not in the habit of burying their dead in the immediate vicinity of their villages, unless they have a church with cemetery attached. However, we found in this case that bodies *had* been buried within 30 feet of the walls of the town. The arroyos *cc*, as already stated, had been washed out by water, and the falling away of the earth disclosed the remains. The first skeleton found was in the right-hand or eastern arroyo, some 6 or 8 feet below the level of the mesa, and had been placed in the grave *face downward*, the head, singularly enough, pointing to the south. This is very interesting and curious, and I am not aware that these two facts have ever been before noticed in regard to American aborigines. As the body lay, we had a fine section of the strata of earth above it. Two feet above the skeleton we noticed two smooth black "ollas," or vases, which, when dug out, were found to contain charcoal, parched corn, and the bones of small mammals and fowls which had doubtless been placed therein at the funeral-feast; and the remaining earth to the surface contained nothing but pieces of charcoal. Not a vestige of clothing, no ornaments, implements, or weapons were found near the corpse, and apparently no receptacle had been employed to contain it. By carefully digging away the surrounding earth with our knives, we were fortunate enough to secure every bone belonging to this skeleton, and it has arrived in Washington in good order, and been presented to the Army Medical Museum.

A further search in both arroyos revealed more bodies similarly buried, and we secured several, but in some cases the crania were wanting. Three or four skeletons of children were also discovered, but the bones were in such fragile condition as to crumble on exposure to the air, consequently we were unable to preserve them.

In examining the anatomical peculiarities of the bones, we were struck with the very large capacity of the cranial vault as compared with the crania of the present Pueblo and other Indians, and the narrowness of the cheek-bones, and the peculiarly attenuated and pointed chin. In two of the skulls the occiput was markedly flattened, whether artificially or not we could not surmise; and in some of the tibiæ the spines were somewhat flatter than those of more recent Indians. In all the skulls found the "ossa triquetra" were numerous. This occurrence is common in most crania of Indians and negroes which I have examined. The size and stature of the individuals during life was probably greater than that of the average aborigine or white of the present day, although the bones, though longer, were much slighter.

We in vain endeavored to find out from the Indians living in the vicinity of Abiquiu if they had any knowledge or tradition regarding the town or burial-places, but none of them seemed to know anything positive, saying, when questioned, that such towns had been built during the time of Moctezuma, and that even the oldest people never remember to have heard from their ancestors that living people had ever been seen there.

There seems but little doubt that at one time this part of New Mexico was densely populated, as in the valley of the Chama we have undoubted evidence of the existence of the ruins of at least six or eight towns which must have been sufficiently large, from present indications, to have contained a total population of two or three thousand. General Simpson, in his valuable report already noted, has made mention of his discovery of quite a number of these ruins south of the Jemez range on the Rio Chama, a tributary of the Rio San Juan, the most interesting being called the Pueblo Pintado. This town, unlike those visited by our parties in the valley of the Chama, was built of compact reddish-gray sandstone in tabular pieces. The town is stated by Hosta, chief of the Pueblos of Jemez, to have been built by Mootezuma and his people when they were on their way from the north toward the south; that after living here for a while they dispersed, some of them going east and settling on the Rio Grande, and others south into Old Mexico. It appears that the people must have been very numerous, if we consider how many of these towns they were able to build. A number of these were seen by General Simpson, and our own parties have also visited a great number heretofore undiscovered, particularly those on the Rio San Juan, south and westward of Tierra Amarilla.

From none of the accounts given of these ruins have I been able to discover that any human remains were found. In fact, it is not certain they have been sought for, and it is hoped that interesting discoveries in this regard may prove an incentive to further exploratory work. It may be mentioned that we also excavated a number of pits in the vicinity of an ancient pueblo near San Ildefonso, N. Mex., but failed to find anything of interest. This town had been built on a mesa overlooking the Rio Grande, and was somewhat similar in character to the one already described.

I should fail in showing my appreciation of favors conferred during the prosecution of this interesting exploration did I neglect to mention that I first heard of the pueblo from Dr. Oscar Loew, the mineralogist of the expedition, who very kindly placed at my service the information he had acquired from Padre Salazar; and I should also state how ably I was seconded in my efforts to obtain the skeletons by Prof. E. D. Cope, and Mr. R. J. Ainsworth, which latter gentleman unfortunately lost his life only three days after he made the excavations by the accidental discharge of a revolver in his own hands.

The following fact is simply stated to show a curious coincidence with the superstition of the Mexicans and Indians: At the pueblo near San Ildefonso Mr. Ainsworth made the excavations for skeletons, I myself not being able to assist, being ill; and at this time he was warned by his Indian guide that those who disturbed the bones of the dead usually suffered from ill luck, or perished violently. How truthfully this prediction was fulfilled is exemplified in his case.

In giving a description of the discovery, I have made no attempt to generalize, but trust that, as experience accrues and further explorations are made, something may be found to throw additional light on the habits and customs of the New Mexican lost races who formerly resided in the neighborhood.

We left Abiquiu September 3, and reached Tierra Amarilla September 4. At this point we had the misfortune to lose our valued friend and topographer, Mr. R. J. Ainsworth, by the accidental discharge of a pistol in his own hands, and I cannot refrain from stating that his loss to the expedition I consider a most serious one. Ever ready to offer his services when they could be made available, conscientious and energetic in the discharge of his duties, he won the respect and love of all those associated with him.

Considerable collecting was done in the vicinity of Tierra Amarilla in reptiles and fishes, and valuable ethnological material was obtained from the Capote Utes and Jicarilla Apaches.

Professor Cope was dispatched to Gallinas Creek to continue his investigations of the fossil deposits, and the writer joined, at Pagosa, Colo., the main party under yourself. At Pagosa from September 14 until September 20 much collecting was done by Mr. Aiken and myself, and many interesting fish from the San Juan River were obtained.

The route pursued by Mr. Aiken, with his notes in regard to his work, are hereinafter given.

Toward the close of May of the present fiscal year, acting under instructions, a party, specially detached, consisting of Dr. J. T. Rothrock, H. W. Henshaw, Mr. Shoemaker, and myself, proceeded to the coast of Southern California, in Santa Barbara County, for the purpose of investigating the so-called grave-mounds on that coast. About a month was spent in this most interesting work, and very valuable results were obtained. The graves in question are comparatively frequent on the coast, and probably extend from north of Moro Bay to San Diego, Cal. They are almost invariably in the immediate vicinity of former villages, and have, doubtless, been used for ages, if the number of skeletons found therein are any criterion to judge by. Of the people themselves who formerly lived upon the coast we have little information. Cabrillo, a Portuguese navigator in the Spanish service, visited the locality in 1542, and mentions

that the entire coast was inhabited by vast numbers of Indians; at this day no remnant of the tribes remain to tell the history of their former numbers or greatness.

In most of the graves examined, loose bones were found within 12 or 15 inches of the surface; but it was only after digging in to a depth of 5 or 6 feet that skeletons in good condition, and surrounded by their implements and utensils, were found.

The inference is, that the same ground had been dug over and over again, and used as a place of sepulchre; the layer of bones near the surface being of older date than those beneath, as the latter were nearly always found carefully deposited in a certain direction.

From these graves we removed a vast number of articles, consisting in part of large and small pots, or ollas, sculptured with artistic skill, from the kind of soapstone known as steatite, or magnesia-mica, quarries of which material exist to the present day on Santa Catalina and Santa Rosa Islands, in Santa Barbara channel; mortars and pestles of sandstone, ornamented with laminæ of the abilone-shell, (*Haliotis spendens,*) fastened to the edges by asphaltum—some of these 26 inches in diameter and of a like depth; war-clubs, or emblems of authority, of sandstone, 30 and 40 inches in length; basins and cups of serpentine, and arrow and spear heads of flint. Many ornaments were found of shell, and quantities of glass beads, of *European workmanship,* which show that many of the burials have been subsequent to Cabrillo's appearance on the coast. I am informed by Dr. Charles Rau that these beads are of Venetian workmanship. Some few iron articles were also found, confirming the latter fact mentioned.

From the graves about 10 or 15 tons of these articles were excavated, and it is thought they will prove of much value and interest.

A fair representation of crania and bones was also obtained. In the explorations we were most kindly assisted by the Rev. Stephen Bowers, of Santa Barbara, who for some time has paid particular attention to the study of the Indian graves of this part of the Pacific coast, and thanks are due to him for the interest manifested. Grateful thanks are also due to Messrs. Thomas W. More, Alexander More, and Joseph Park of La Patera, and to Mr. Welch of Dos Pueblos, upon whose properties the excavations were made.

It is with no little satisfaction that reference is made to the extended collections secured. The constantly improving arrangements made for the better prosecution of the zoological and botanical work shows more and more how much can be accomplished at a trifling expense.

The following schedule shows the numbers of specimens actually obtained.

SCHEDULE.

List and numbers of zoological specimens collected in 1874.

Mammals, comprising alcoholics, skins, and crania	67
Birds, comprising alcoholics, skins, crania, sternæ, nests, and eggs	1,450
Fishes, comprising alcoholics and skins	1,660
Reptiles, alcoholics	280
Insects, Orthoptera, (grasshoppers,) 105 lots, probably	2,500 or 3,000
Coleoptera, (beetles,) 60 lots, probably	2,000 or 3,000
Lepidoptera, (butterflies,) including *Zygenidæ* and *Bombycidæ*	428
Hymenoptera, (wasps and bees,) 90 lots, probably	4,500
Diptera, (flies,) 17 lots, probably	170
Hemiptera, (bugs,) 67 lots, probably	1,500
Neuroptera, (dragon-flies,) 41 lots, probably	200
Formicariæ, (ants,) 30 lots, probably	2,000
Arachnidæ, (spiders,) 54 lots, probably	600
Mollusca, (shells,) 22 lots, probably	500
Worms, Leeches, and *Crustacea,* 52 lots, probably	600

In addition, about 200 crania of Indians were obtained, and a large collection of archæological and ethnological material; 55 lots of modern articles, and 57 boxes of stone and other implements from the graves of Southern California.

Of botanical specimens, about 9,000 were collected.

All of which is respectfully submitted.

H. C. YARROW,
Acting Assistant Surgeon U. S. A.,
Surgeon and Zoologist to Expedition.

First Lieut. GEO. M. WHEELER,
Corps of Engineers U. S. Army, in charge.

II.—NOTES UPON THE ORNITHOLOGY OF THE REGIONS TRAVERSED.

By H. W. Henshaw, ornithological assistant.

An interval of nearly three weeks spent at Santa Fé was occupied in examining the country in the vicinity of the town. The results, however, were comparatively meager and unsatisfactory, as indeed was to have been anticipated from the barren character of the region accessible. Quite a number of birds were secured; perhaps the most interesting species noted here being the black-throated gray warbler, (*Dendroica nigrescens*,) which was probably breeding among the piñons of the foot-hills.

Leaving Santa Fé June 26, our march led to Fort Wingate, very little of interest to any of the party being observed *en route*. Birds were found tolerably numerous at several of the streams crossed, where the brush-lined banks afforded at once places of shelter for themselves and their nests, and also favorable hunting-grounds for food. Several of the desolate stretches of plain were found to be inhabited by the Rocky-Mountain plover, (*Ægialitis montanus*,) and on two occasions the young just from the egg were found. The rapid marches, which were made in order the earlier to reach more interesting fields for work, precluded the making of any extended collections, and we contented ourselves with observing such facts as came immediately to our notice.

The same lack of interesting animal-life attended the march from Wingate toward Apache, little of interest being recorded. A short distance to the south of the Little Colorado River a very rare vireo, (*V. vicinior*,) of which but a single specimen was known, was met with, and there secured.

Reaching the Sierra Blanca, a camp was made at Willow Spring, at an altitude of little over 7,000 feet. Here a stay of three days was busily occupied in securing such collections of both flora and fauna as the brief time permitted. The heavy pine-timber interspersed here and there, with beautiful groves of thrifty oaks, afforded a home for many species of birds, of which not a few were represented by many individuals. The discovery of the *Cardellina rubrifrons* as an inhabitant of the Territory, a little bird, combining in its habits peculiarities of both the titmice and warblers, was made. Of particular interest were the birds *Junco*, var. *dorsalis*, of which a nest with eggs was secured, and the hepatic tanager, (*Pyranga hepatica*.) This latter species was known only in this Territory, from a single specimen taken several years ago. Both in 1872 and 1873 it was found from this point to the southern border, and is common in many localities.

Keeping to the south from Camp Apache, abundant opportunity was found along the route for making collections, and scarcely a camp or day's march was made without some valuable object of natural history being obtained.

Between Camp Apache and the Gila River several species of birds were noticed for the first time, their extension to the northward in this section finding approximately its limits. Such are *Peucæa ruficeps*, var. *boucardi*, a near relative of the brown-headed finch of the Pacific coast, the *Peucæa cassini* and *Setophaga picta*. A large fly-catcher, the *Contopus pertinax*, was found common on the edges of the pine-woods and the rocky ravines, though this species probably reaches some distance north of Apache. At Ash Creek, quite a number of fish were taken with hook and line, and also a turtle, which has proved to be of a rare and little-known species, *Cinosternum henrici*. Crossing the Gila, we continued to the south, toward Camp Grant, reaching this point July 28. On the road the oriole (*Icterus cucullatus*) was seen, it apparently not crossing the Gila to the north. After several days' reconnaissance in the immediate vicinity of the post, where several small streams make their way down from the adjoining mountain-chain and lose themselves in the thirsty sands of the barren plain a few miles out, four days were spent on Graham Peak; and here, at an elevation of nearly 10,000 feet, abundant opportunity was had for collecting. Of birds, many species were noted, while the number of each species was usually great. Special mention may be made of three species to which particular interest attaches. The *Cardellina rubrifrons* was found to inhabit these mountains in great numbers, the Sierra Blanca, to the north, probably forming its northern limit. The Mexican snow-bird, (*Junco cinereus*,) was a second species not known to inhabit the Territory, and their numbers were so great here as to justify the belief that this point by no means marks the limit to their northward range; and it seems probable that investigation to the north would reveal the fact of the complete coalescence of this form with that of its close relation, the *Junco dorsalis*, which was the only variety found in the Sierra Blanca, quite seventy-five miles farther north. Several fine specimens of the *Eugenes fulgens*, the large humming-bird, obtained here the previous season, were secured, and also a nest discovered. Besides the dwarf variety of the white-tailed deer, mentioned by Dr. Rothrock, and black bear, many of the smaller mammals, especially several rodents, were numerous. The black-footed gopher, (*Thomomys umbrinus*,) was present about the lumbermen's camp in astonishing numbers, traces of their labors in the shape of tunnels and burrows being seen in all directions, while in the early morning and evening the little animals themselves were frequently visible as they cautiously emerged from their holes in search of the corn scattered about

by the stock. A night's march brought us to Camp Bowie, the tedium of the road being broken by the songs of the Cassin's finch, (*Peucœa cassini.*) a small sparrow abounding in this section, and which at this season has the unusual habit of continuing its plaintive melody through the entire night.

From August 6 to the 19th the interval was occupied in collecting about Camp Bowie and also in the vicinity of the neighboring agency. A large number of birds were obtained, among them a humming-bird, (*Doricha enicura,*) a beautiful species, known only from far south in Guatemala. The ground-squirrel (*Spermophilus grammurus*) is an abundant resident of this region, and the curious fact was ascertained here that it has made itself very obnoxious to the settlers by its raid on their henneries, proving itself an adept at stealing the eggs.

From here until we camped at the base of the Santa Rita Mountains work was prosecuted chiefly as we marched along, and nothing of especial interest was observed. Here several valuable contributions both to our botanical and zoological collections were made. Three species of birds, new to our fauna, were obtained, viz: *Myiodynastes luteiventris*, *Circe latirostris*, and *Picus stricklandi;* the evidence sufficiently proving that all these are summer residents in this region. The Arizona sparrow (*Pevcœa æstivalis*, var. *arizonæ*) was found abundant in the neighboring Sonoita Valley.

Retracing our steps, we turned aside to visit Camp Lowell, arriving there September 8. Perhaps on no single point on our long route was the number of birds found so great as here, and the five days spent in this locality were well rewarded. The desert plains over which our approach to the post was made is the home of several rare forms of bird-life, that are especially adapted for an existence under conditions which would appear most unfavorable. The Bendires thrush, (*Harporhynchus*, var. *bendireii,*) a recently-discovered bird the Palmer's thrush, (*H.* var. *palmeri,*) and the cactus wren, (*Campylorynchus brunneicapillus,*) were all more or less abundant about the various species of the cacti which are scattered over the plains here in every direction, and form, indeed, in places almost the only phase of vegetation; in others being varied only with the equally desolate-appearing grease-wood and sage-brush. Near the stream which passes by the post the undergrowth was found alive with feathered life, many species of birds finding favorable conditions for a winter-resort. Among these were found numbers of the Rufus-winged sparrow, (*Peucœa carpalis,*) and pains were taken to secure a good suite of this little-known species. Returning from here to Graham Peak, September 18, a ten-days' camp was made, and, besides a large number of specimens, two species of birds new to the fauna were found, (*Peucedramus olivacea,*) and the Mexican cross-bill, (*Curvirostra*, var. *mexicana.*) The Townsends and western warblers (*Dendroica townsendi* and *D. occidentalis* were also found quite numerous. Returning to Camp Apache via San Carlos, that post was reached October 10. The opportunity was now taken to visit the interior and higher parts of the Sierra Blanca, though the lateness of the season seemed to preclude the probability of much being accomplished in the line of zoology. Such proved to be the case, the deep frosts being found to be almost destitute of animal life.

A curious species of owl, which, instead of possessing the usual nocturnal habits, is abroad only in the earlier part of the morning and during the late afternoon, was found to be very numerous in the piny ravines, where they appeared to associate in regular companies, a rather anomalous fact in birds of that family. Dusky grouse (*Tetrao obscurus*) were found to be not uncommon in the high pine ridges, and this is to be regarded with great probability as about the most southern limit to this species, no other of the family extending thus far, or being known at all from Arizona.

With our return to Apache terminated practically the field-work; the late season, combined with the rapidity of our subsequent marches to Santa Fé, preventing any results of importance.

Respectfully submitted.

H. W. HENSHAW.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

III.—NOTES ON THE ORNITHOLOGY OBSERVED BY MR. C. E. AIKEN, ASSISTANT.

My operations for the season of 1874 commenced at Pueblo, Colo., on the 23d of July.

Few mammals were noted from this locality, but several species were very abundant. Of these, the prairie-dog (*Spermophiles ludovicianus*) were most numerous; but coyotes, swifts, badgers, hares, and rabbits were also common. I was interested to see, at Pueblo, a cub of the grizzly bear, (*Ursus ferox,*) which had been captured in the adjacent Greenhorn Mountains. This settles the doubts heretofore existing as to the occurrence of this bear on the eastern slope of the Rocky Mountains.

Ornithological collecting at Pueblo was very unsatisfactory. Much of the river-bottom, once cultivated, was now destitute of any vegetation save weeds, and the unfenced

groves of cottonwood had been stripped of their undergrowth, so necessary to the existence of the feathered tribe, by the various herds of stock that daily resorted to them for shelter from the burning rays of the noonday sun. The foliage of the trees was shriveled by the intense heat and laden with dust, presenting anything but a tempting resort for the timber-loving species.

Two weeks of careful scrutiny in this locality revealed the presence of about fifty species of birds, all of which had doubtless bred in the vicinity, as in most cases the old birds were found in attendance upon their young. Owing to the lateness of the season, no eggs whatever were obtained, and in only three or four instances were birds found so young as to be unable to fly. Several species were evidently preparing for their southern migration.

Six or seven species were very abundant, of which were the red-winged and Brewer's blackbirds; also the doves and grass-finches. These frequent the more open ground. In every clump of the larger trees, dozens of the noisy, but handsome, red-headed woodpecker made themselves conspicuous; and in the more sheltered groves, the short-legged pewee outnumbered all other birds. The kingbirds and Arkansas flycatchers also were quite common among the scattered timber, the latter uttering its discordant notes from the tops of the tallest trees. Among the more interesting birds noticed here were the black-headed and blue grosbeaks, long-tailed mocker (*Mimus polyglottis*, var. *caudatus*), Arkansas-finch (*Chrysomitris palustris*), and the savanna-sparrow, the last species, which is identical with the eastern *passerculus*, being here found breeding for the first time in Colorado. A nest of Swainson's buzzard was found containing newly-hatched young as late as the 1st of August, being an instance of the irregularity of breeding in this bird, which frequently lays its eggs as early as the 15th of April.

Of reptiles seven or eight representatives were found, and nine or ten of fishes, but the insect class was represented in a superlative degree. An examination of the rank growth of coarse vegetation which is so abundant in the river bottom revealed hymenoptera, lepidoptera, diptera, coleoptera, hemiptera, and orthoptera, in varieties and numbers that were not equaled at any point subsequently visited.

Leaving Pueblo on the 5th of August, our route lay to the southward, along the plains at the base of the Greenhorn range to Badito, thence over the Sangre de Cristo Mountains to Fort Garland, which was reached on the 14th. Among the more note-worthy birds noticed on the plains, were the mountain mocking-bird, (*Oreoscoptes montanus*,) long-billed curlew, and the burrowing owls, (*Speotyto cunicularia*, var. *hypugæa*,) the latter being found only in the vicinity of prairie-dog towns. They are found standing on the mounds of dirt before prairie-dog holes, and are remarkably sharp-sighted and wary for birds of their family, it being often difficult to get within long gun-shot of them. On being disturbed, they rise with a chattering cry, and fly a short distance, then resuming their watch from another mound. When wounded, they take refuge in the nearest hole, from which it is useless to try to secure them. The story so widely circulated, which gives this bird the credit of living peaceably in the same hole with rattlesnakes and prairie-dogs, must be taken with a liberal grain of allowance. It is true that owls, snakes, and rabbits live in holes dug by the prairie-dogs, but only in deserted ones; and after three seasons of observation of these animals, I have yet to see a single indication that any two of them live together in the same burrow. The den of the burrowing owl may be recognized among a thousand prairie-dog holes by the pile of bird-dung at its entrance. As we entered the piñon-clad hills at Badito, a number of birds were seen, which had not been previously met with; among others, the noisy and restless piñon-jay, (*Gymnokitta cyanocephala*,) which was seen scattering along, from one hill to another, in flocks of fifteen or twenty birds. In proportion as we advanced higher into the mountains, wild-bird life diminished, and at the altitude of 10,000 feet we missed nearly all of the low-land species, and found in their stead such birds as the long-crested jay, green-tailed and Lincoln's finches, and the merry little mountain titmice. The 13th of August, spent in ornithological observations in the vicinity of the Sangre de Cristo Pass only brought to light about a dozen species of birds; most of these were apparently migrating, and the entire absence of others from their favorite summer-haunts showed that they had already left for the south.

Descending to the altitude of about 7,000 feet, at Fort Garland, the scarcity of many birds that had been common at the same altitude along the eastern foot-hills was remarked, among them the black-headed grosbeak, long-tailed chat, lazuli finch, and arctic towhee, which were either rare or entirely wanting. At this place, numbers of the rufous-backed hummers were observed along the creek-bottoms, where they had doubtless halted in their migration southward. The capture of this species at this place is an interesting circumstance, for, although it has been reported as occurring here, I think there is no authentic instance of its capture in the Territory on record. The creeks of the vicinity, as is the case with nearly all branches of the Rio Grande, are abundantly stocked with trout, (*Salmo pleuriticus*,) and evidences of beaver are seen everywhere in the stumps of the trees cut down by them. At one point on Ute Creek, within a mile of the fort, I noticed a number of trees, from 8 to 12 inches in diameter, which

had been felled by these singular animals, and apparently without design; for they lay just where they had fallen, and even the smaller twigs had not been disturbed. On the small streams in the mountains, to the eastward of Fort Garland, where several days were passed, the devices of the beaver to increase the depth of the water were constantly seen in the form of dams, which were sometimes so abundant as to form a succession of small ponds, the water flowing over the dam of one only to fall into the basin of another.

In these mountains, signs of bear and elk were seen in different places and numbers of the mule-deer (*Cervus macrotus*) were seen. The sprightly little four-lined squirrel (*Tamias striata*) scampered before us as we forced our way along the pathless mountain sides, and Richardson's squirrel (*Sciurus richardsoni*) barked saucily at us from his retreat in the thick-foliaged spruce-tree. A weasel and two or three species of mice, among the latter the curious kangaroo, or jumping-mouse, were also noticed. The scarcity of birds here was probably due largely to the lateness of the season. Among the willows that fringe the streams, the green-tailed finch and McGillivray's warbler found hiding-places, and, as they were now moulting, were more than usually shy. Sometimes the harsh, grating notes of Clark's nut-cracker, uttered far up the side of the mountain, or the shrill cry of the red-tailed hawk sailing overhead, broke the death-like silence, and a troop of mountain tits or ruby kinglets flitting through the forest, and perhaps a flock of the gray-headed snow-birds, relieved it temporarily of its solitude. On two or three occasions covies of dusky grouse were flushed, the birds taking refuge in the tall spruce-trees, where they would stupidly sit with outstretched necks until brought down by the shot-gun.

Such was the character of the country that formed my collecting-field during three-fourths of the season; rugged spruce and aspen clad mountains at an elevation of from 8,000 to 12,000 feet; and the birds and mammals here noticed were, with few exceptions, the only forms found in such localities.

My visit to the above mountains was attended with one excellent result, the detection of the band-tailed pigeon (*Columba fasciata*) at the western base of the Spanish Peaks. This bird, a prize to obtain at any locality, had never previously been obtained, or its existence even expected in Colorado. Several were seen at this place, and later in the season, September 20, I was fortunate enough to meet with them again in considerable numbers about fifteen miles above the town of Del Norte, on the Rio Grande. At the latter place, a flock of twenty of these pigeons was found, and I learned from persons living in the vicinity that the same birds had been noticed throughout the summer; so they had doubtless raised their young there. In their habits they resemble the common wild pigeon, (*Ectopristes migratorius*.) They fly in compact flock, and frequent both the conifers of the mountains and the cottonwood groves of the river-bottom, though apparently preferring the latter. On the Rio Grande, they were feeding greedily upon a small white berry that grew abundantly upon the river-bank.

Leaving the mountains in the vicinity of Fort Garland, our party proceeded southward and westward, through the great San Luis Valley, and then ascended the Conejos River to its source. The sage-plains of the San Luis Valley were frequented by numerous migrating sparrows, most abundant among which were the little Brewer's sparrows; and the most interesting, because not previously noticed in Eastern Colorado, were the Bell's finches, (*Poospiza belli*, var. *nevadensis*,) of which two flocks were seen, though owing to their shyness, and my lack of time, only one specimen was secured. On a high barren plain near the crossing of the Rio Grande, a single specimen of Baird's sparrow (*Centronyx bairdi*) was seen and obtained; an interesting capture, notwithstanding the fact that this has, during the past two years, been proved an abundant species in Dakota and Arizona. In the Conejos cañon, Townsend's warbler, a little-known bird, and new to this section of the United States, was secured. It was in company with a flock of California nut-hatches, (*Sitta pusilla*, var. *pygmæa*,) in the spruce-timbers bordering the valley. Although this species was only met with on one other occasion, I am lead to believe that it is not uncommon during the migrations in the mountains of Western Colorado.

In the valley of the Conejos River, several forms of animal life were abundant. Foxes were daily seen, and bands of deer and antelope were on several occasions surprised by different members of the party. Beaver were very plentiful, as also were minks and several smaller mammals. The largest trout caught during the season, measuring 21½ inches in length, was taken from the waters of the Conejos.

Far up on Summit Peak, where this river has its source, the common woodchuck (*Arctomys empestra*,) was numerous, living in burrows and crevices among the masses of loose rocks; and the rocky slides were the homes of conies, (*Lagomys princeps*.)

Above the line of timber, at an altitude of 13,000 feet, a very interesting bird, the white-tailed ptarmigan, was found in large numbers. One flock of twenty-five, and several smaller ones, were seen, from which fourteen birds were killed in a short time. They were very unsuspicious, and would sometimes run along the ground before me like a domestic fowl, but, after being once flushed and thoroughly frightened, they would lie so close in the scant cover that it was almost impossible to find them.

Another interesting bird obtained in the same place was Allen's finch, (*Leucosticte australis.*)

On the 5th of September we arrived at Pagosa Springs, Colo., which point was made the headquarters of our party for two weeks, giving me an opportunity to reconnoiter the surrounding country for zoological specimens. About eighty species of birds, including those observed on a trip to the Gallinas Mountains, were observed within a circuit of fifty miles. The country which this short trip covered was more interesting to an ornithologist than any other of the same extent visited during the season, and it is to be regretted that more time could not have been spent there. Nothing new taken, but the character of the country is well suited to the wants of birds, and both land and water species were numerous.

Abundant evidence was had of bear and black-tailed and white-tailed deer all through this section, but the smaller mammals were sparsely represented; even the little chipping squirrel, which had been so common, and which we had come to look upon as a component part of the wilderness, we seldom saw here. Owing probably to the lateness of the season, there were very few insects; but several interesting species of fish were taken from the waters of the San Juan river.

We left Pagosa on the 21st of September, and returned to Pueblo by way of Del Norte and Fort Garland. One day was passed at the San Luis Lakes, a series of marshes and alkaline ponds about thirty miles north of Garland, which offer attractions to water-birds unsurpassed by any other spot in Colorado. At this season, October 3, I found large numbers of water-fowl congregated about them. Along the sandy shores of the larger ponds, flocks of Baird's sand-pipers and avocets found abundant food, for in all these alkaline waters are myriads of small marine insects. The marshes swarmed with ducks, of which there were nine or ten species, and on the open water rafts of beautiful snow-geese floated serenely. Besides the snow-geese, three others were common, which, although seen only from a distance, I have little doubt were respectively *Anser albifrons*, var. *gambelli-Brenta canadensis* and *Brenta canadensis*, var. *hutchingsi*. On the shores of the largest lake, which is four or five miles in circumference, I saw a singular sight—the bleached skeletons of numerous ducks, mainly of the species *Erismatura rubida*, half buried in the dry sand. I can only account for this phenomenon by supposing that an epidemic had prevailed among the ducks during the previous spring.

The journey from Fort Garland to Pueblo being by stage, few opportunities for collecting were afforded after leaving the former place.

The results of my season's collecting, as a whole, were perhaps as good as could have been expected under the circumstances. Our party being more particularly a topographical one, and natural-history collections a subordinate consideration, the collector labored under disadvantages, and it was impossible to give any particular locality full attention; and usually the only time available for the preservation of specimens obtained during the day's march was at night, by a candle's dim light. In addition to these obstacles, the country surveyed this year was an elevated mountainous tract, which, although well watered and rich in vegetation, was, owing largely, I think, to the lateness of the season, almost destitute of animal life in many places.

Respectfully submitted.

CHAS. E. AIKEN.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

APPENDIX I 2.

ANNOTATED LIST OF THE BIRDS OF ARIZONA, BY H. W. HENSHAW, ORNITHOLOGICAL ASSISTANT.

The following list comprises all the birds known to have been taken or observed within the territorial limits of Arizona. In its compilation several sources have been drawn upon. A large proportion of the whole number were either collected or passed under the observation of the author or others of the expedition during the seasons of 1873 and 1874.

The portion of Arizona visited by the survey was the eastern section, from a point a little to the north of Camp Apache south to the border-line. In 1873, the time inclusive from July 15 till late in October was spent in this portion of the Territory, and in 1874, from early in July until the last of November, opportunity being thus afforded to investigate pretty thoroughly the summer fauna embraced within the line of operations, as well as to acquire information regarding the winter-residents.

In addition to the material thus gathered, I have freely availed myself of the published notes of others, chief among these being the list of Arizona birds published by Dr. Coues in 1866, which embraced, besides the birds observed by him at Fort Whipple,

in the west-central portion of the Territory, all others collected earlier by the various Government exploring expeditions, as well as those of Dr. J. G. Cooper, made at Fort Mojave, on the Colorado River; thus affording a complete index of the fauna up to that time. Since then many interesting facts have been brought to light by the labors of Captain Bendire, principally in the neighborhood of Tucson, where he found several species new to the fauna. To him I am also indebted for a list of the species found in the vicinity of Tucson in 1872, indicating those breeding and such as winter and are resident. The list may thus be regarded as affording a pretty complete idea of the Ornis of the Territory, and it is not likely that many species remain to be added, except along the southern border. Of Mexican birds, that extend across our lines, and find their northern limits within our areas, there, doubtless, yet remain quite a number to be discovered, and these not mere stragglers, but such as exist in considerable numbers. These will probably be found principally in the southeast, as there the mountains, continuing in an unbroken range from the table-lands of Mexico, afford a highway, as already ascertained, for quite a number of otherwise extralimital forms, which will be still further swelled by additional research.

In order to afford means of comparison between the species occurring in the eastern part and those found at Fort Whipple and in the Colorado Valley, attention is called to the differences in relative abundance, as also to the time of year when this difference occurs. When no especial locality is given, the remarks will be understood to apply to the Territory generally. An asterisk prefixed to the number indicates those that breed within the Territory.

Respectfully submitted.

H. W. HENSHAW.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

TURDIDÆ. The Thrushes.

*1. *Turdus migratorius* L. Common Robin. Quite numerous during migrations. Not very common in summer. Resident.

*2. *Turdus pallasi* Cab., var. *auduboni* Bd. Audubon's Thrush. An abundant summer resident in high mountain districts.

3. *Turdus pallasi* Cab., var. *nanus* Aud. Dwarf Hermit Thrush. "Rare; spring and autumn migrant; some breed" (Coues). None, it is thought, remain during summer.

4. *Turdus nævius* Gmelin. Varied Thrush. Obtained on Colorado River by Lieutenant Ives's expedition, where, however, it was probably accidental.

*5. *Oreoscoptes montanus* (Towns.). Sage Thrasher. Common; resident. "Winters about Tucson" (Bendire).

*6. *Mimus polyglottus* L. Mockingbird. Common; summer resident. Very numerous at localities in the southeastern part of the Territory.

*7. *Harporhynchus cinereus* Xantus, var. *bendirei* Coues. Bendire's Curve-billed Thrush. So far as known, confined to extreme southeastern part of Territory, where it is common, especially about Camp Lowell. "Breeds, and is resident" (Bendire).

*8. *Harporhynchus curvirostris* (Sw.), var. *palmeri*, Ridgway. Palmer's Curve-billed Thrush. More numerous than preceding, and, like it, an inhabitant of the arid plains. "Resident" (Bendire).

9. *Harporhynchus redivivus* (Gambel), var. *lecontei* (Laws.). Le Conte's Curve-billed Thrush. Type from Fort Yuma. A second specimen taken by Dr. Coues near Fort Mojave. Probably resident. Apparently not occurring in the southeastern portion.

*10. *Harporhynchus crissalis* (Henry). Crissal Thrush. Occurring in all the region south of the Gila River; generally preferring rocky hills. Resident.

CINCLIDÆ. The Dippers.

*11. *Cinclus mexicanus*, Sw. Water Ouzel. Detected only in the White Mountains where it is resident.

SAXICOLIDÆ. The Saxicolas.

*12. *Sialia mexicana* (Sw.). The Mexican Bluebird. Abundant; resident from the plains to high mountainous localities.

13. *Sialia arctica*, Sw. The Arctic Bluebird. Perhaps only a winter visitant; though not unlikely the mountains of the northern part may afford it a summerhome.

SYLVIIDÆ. The Sylvias.

*14. *Regulus satrapa* Licht. The Golden-crested Wren. Stated by Dr. Coues to have been taken in the Territory, though not met with by himself. Probably very rare.

* 15. *Regulus calendula* (L.). The Ruby-crowned Wren. In the southeastern part, a rather common summer inhabitant of the mountains. As a migrant, very abundant. Some probably winter.

* 16. *Polioptila cœrulea* (L.). Blue-gray Gnatcatcher. "Rare; summer resident" (Fort Whipple, Coues). In summer, sparingly, though quite generally, distributed in eastern part. "Winters in Colorado Valley" (Cooper).

17. *Polioptila plumbea*, Bd. Lead-colored Gnatcatcher. Have never met with it. Said by Dr. Coues to be "generally distributed throughout Arizona, though nowhere very abundantly". "Winters in Colorado Valley" (Cooper). Resident about Tucson (Bendire).

*18. *Polioptila melanura* Lawr. Black-capped Gnatcatcher. Fort Yuma (Ives); Pima villages, Southern Arizona (Heermann). Breeds and is resident about Tucson (Bendire).

PARIDÆ. The Titmice.

*19. *Lophophanes inornatus* (Gamb). Gray-tufted Titmouse. Common resident. Frequents the piñon-covered hills, and in the south the oaks, never the pine woods.

*20. *Lophophanes wollweberi* Bon. Wollweber's Titmouse. Common; permanent resident at Fort Whipple (Coues). In the southeastern part quite abundant, affecting chiefly the oaks.

*21. *Parus montanus* Gamb. Mountain Chickadee. A common resident of the pine woods of the mountains throughout the Territory. The Western Black-cap Titmouse (*P.* var. *septentrionalis*) remains to be discovered in Arizona. It occurs both in Utah and Southern Colorado (Fort Garland, Aiken; Henshaw), and probably reaches into the northern portion, at least, of Arizona.

*22. *Psaltriparus minimus* (Towns.), var. *plumbeus* Bd. Lead-colored Tit. An abundant resident. Inhabits the piñons, or the brush of the cañons and ravines.

* 23. *Auriparus flaviceps* (Sund.). Yellow-headed Titmouse. "Abundant in the Colorado Valley, where it is a permanent resident" (Cooper). "Breeds about Tucson" (Bendire). Apparently not very common in the southeastern part, where it is confined to the warm valleys.

SITTIDÆ. The Nuthatches.

* 24. *Sitta carolinensis*, Gm., var. *aculeata* Cass. Slender-billed Nuthatch. Resident. Common summer inhabitant of the pine tracts of the mountains, moving low down in winter.

25. *Sitta canadensis* L. Red-bellied Nuthatch. Fort Yuma (Ives). Probably rare, yet may occur even in summer in the northern portion of Territory, as it was not uncommon in mountains of extreme Southern Colorado.

* 26. *Sitta pusilla* Lath., var. *pygmœa* Vig. Pigmy Nuthatch. Most abundant of the family. Resident in the pine region.

CERTHIIDÆ. The Creepers.

* 27. *Certhia familiaris* Vieill., var. *americana* Bon. Brown Creeper. Of not uncommon occurrence in the mountains to the Mexican border, where probably resident. The Mexican creeper (var. *mexicana*), though known from the high table-lands of Mexico, has not yet been detected within our limits.

TROGLODYTIDÆ. The Wrens.

* 28. *Campylorynchus brunneicapillus* (Lafr.). Cactus Wren. Of common occurrence in the region south of the Gila River; also on the Southern Colorado. The cactus plains are their favorite resorts, though they also frequent the thickets and shrubbery. Resident.

* 29. *Salpinctes obsoletus* (Say). Rock Wren. In many sections very abundant. Resident. A true rock-dweller.

* 30. *Catherpes mexicanus* (Heerm.), var. *conspersus* Ridgway. White-throated Rock Wren. "Generally distributed over the southern and western portions of the Territory" (Coues). Also in eastern and southeastern parts; never found in large numbers as the preceding. Resident.

* 31. *Thryothorus bewicki* (Aud.), var. *leucogaster* Ridgway. "The most abundant and characteristic wren of Fort Whipple" (Coues). Generally, but rather sparingly, distributed in the eastern and southeastern portions. Resident.

* 32. *Troglodytes aëdon* Vieill., var. *parkmani* Aud. Parkman's Wren. Very common everywhere, from the mountain tops to the plains. Winters about Tucson (Bendire).

* 33. *Cistothorus palustris* (Wils.) Long-billed Marsh Wren. A common summer resident in all localities suited to its palustrine habits.

MOTACILLIDÆ. The Wagtails.

34. *Anthus ludovicianus* (Gm.). Titlark. Occurs in varying numbers as a winter visitant.

SYLVICOLIDÆ. The Warblers.

35. *Helminthophaga ruficapilla* (Wils.). Nashville Warbler. Quite common about Camp Crittenden, in southeastern part of the Territory, during latter part of August.

*36. *Helminthophaga virginiæ* Bd. Virginia's Warbler. Apparently more numerous to the north, especially in Colorado; not uncommon, however, in the White Mountains of the eastern part of Territory in August, where it probably breeds. "Very rare; summer resident" at Fort Whipple (Coues).

*37. *Helminthophaga luciæ* Cooper. Lucy's Warbler. Summer resident; breeding at Fort Whipple; arrives the second and third weeks in April; remaining until latter part of September (Coues). "Breeds also about Camp Lowell, in southeastern portion of Territory" (Bendire). Seems to be absent from the eastern part generally.

*38. *Helminthophaga celata* Say. Orange-crowned Warbler. From records appears to be quite generally distributed throughout the Territory, as it certainly is in the eastern portion, though nowhere common.

*39. *Dendroica æstira* (Gm.). Yellow Warbler. Common summer resident.

*40. *Dendroica auduboni* (Towns.). Audubon's Warbler. In the eastern portion at least a common summer resident among the pines of the mountains, where it breeds. Very abundant everywhere as a migrant.

*41. *Dendroica graciæ* Coues. Arizona Warbler. "Common among the pines of Fort Whipple in summer (Coues). Numerous also in the White Mountains in Eastern Arizona. Breeds in the pine region.

*42. *Dendroica nigrescens* (Towns.). Black-throated Gray Warbler. Quite an abundant species among the pines of Eastern Arizona, where they breed. "Common at Fort Whipple; chiefly spring and autumn migrant; but a few breed" (Coues).

43. *Dendroica townsendi* (Nutt.). Townsend's Warbler. Common during fall migration in Southeastern Arizona; chiefly affect the spruce-woods of the mountains; some, however, are found lower down in the valleys. A few possibly breed.

*44. *Dendroica occidentalis* (Towns.). Western Warbler. Same as preceding. Given by Dr. Coues as very rare summer resident at Fort Whipple.

45. *Peucedramus olivacea* (Giraud). Olive-headed Warbler. Three specimens taken at Mount Graham, in Southeastern Arizona, in September. Probably breeds.

46. *Seiurus noveboracensis* (Gm.). Water Thrush. A single individual found near Camp Crittenden, in the southeastern portion of Territory, the last of August. Probably small numbers pass through during the migrations.

*47. *Geothlypis trichas* (L.). Maryland Yellow throat. Noted as a rare summer resident at Fort Whipple by Dr. Coues, as it appears to be elsewhere. Seen in the eastern portion only once or twice. "Breeds about Tucson" (Bendire).

*48. *Geothlypis macgillivrayi* (Aud.). McGillivray's Warbler, Common summer resident; inhabits the thickets of the streams; also the mountains up to 9,000 feet. "Winters about Tucson" (Bendire).

*49. *Icteria virens* (L.), var. *longicauda* (Lawr.). Long-tailed Chat. Common summer resident. Frequents the brush-lined streams of the low-lands generally.

*50. *Myiodioctes pusillus* (Wils.). Wilson's Blackcap. Very abundant during the fall migration. "A summer resident at Fort Whipple" (Coues). "Breeds about Tucson" (Bendire).

*51. *Setophaga picta* (Sw.). Painted Flycatcher. Occurs in the mountainous districts of the southeastern portion, from Camp Apache southward. Summer resident.

*52. *Cardellina rubifrons* Giraud. Red-faced Warbler. Occurs as a summer resident at least as far north as Camp Apache. Very numerous at Mount Graham in August; inhabits the pine region.

HIRUNDINIDÆ. The Swallows.

*53. *Progne subis* (L.). Purple Martin. Abundant summer resident of the mountains. Breeding in colonies in the holes of trees.

*54. *Petrochelidon lunifrons* (Say). Cliff Swallow. Abundant wherever they find suitable cliffs for nesting purposes. Summer resident.

*55. *Hirundo horreorum* Bart. Barn Swallow. "Numbers seen migrating through Fort Mojave", May 25, 1861, (Cooper). "Breeds at Tucson" (Bendire). I do not now remember to have seen this swallow in Eastern Arizona, although it occurs in New Mexico close to the line, and doubtless is interspersed in small numbers here and there in Arizona.

*56. *Hirundo bicolor* Vieill. White-bellied Swallow. "Breeds about Tucson" (Bendire).

* 57. *Hirundo thalassina* Sw. Violet-green Swallow. Abundant. Breeding usually in colonies of greater or less numbers in the mountain districts.
* 58. *Stelgidopteryx serripennis* (Aud.). Rough-winged Swallow. A quite generally distributed summer visitant. Abundant in some localities.
* 59. *Cotyle riparia* (L.). Bank Swallow. "Rare summer resident at Fort Whipple" (Coues). "A summer visitor near Tucson" (Bendire).

VIREONIDÆ. The Vireos.

* 60. *Vireo gilvus* (Vieill.), var. *swainsoni* Bd. Western Warbling Vireo. Common summer resident of the Territory generally; in the mountains up to 10,000 feet.

61. *Vireo solitarius* (Wils). Solitary Vireo. Quite numerous in the pine region at Mount Graham, in the southeastern portion of the Territory, the latter part of September.

62. *Vireo solitarius* (Wils.), var. (?) *cassini* Bd. Cassin's Vireo. Quite numerous at Camp Crittenden during the latter part of August, where they frequented the deciduous trees. Also found in fewer numbers at Mount Graham in September, among the pines. Apparently occurs in Arizona only as a migrant from the north.

* 63. *Vireo solitarius*, Bd., var. *plumbeus*, Coues. Lead-colored Vireo. Common. Generally found in summer among the pines of the mountains, where they breed.

64. *Vireo belli* Aud. Bell's Vireo. A single specimen of this species, of which the following may be but the western variety, was taken on the Gila River September 16.

* 65. *Vireo pusillus* Coues. Least Vireo. Fort Mojave (Cooper). "Breeding abundantly fifty miles south of Fort Whipple" (Coues). Many were found breeding on the brush-lined creeks near Camp Grant. Apparently confined to the low regions, where it inhabits the brushy thickets.
* 66. *Vireo vicinior* Coues. Arizona Vireo. Rare, but quite widely distributed in Eastern Arizona. A summer resident. The type was from Fort Whipple, where it was "very rare."

AMPELIDÆ. The Chatterers.

67. *Ampelis garrulus* (L.). Northern Waxwing. "A winter visitant from the north to the more northern portions of the Territory" (Coues). "Fort Mojave, January 10, 1861" (Cooper).

* 68. *Ampelis cedrorum* (Vieill.). Cedar Bird. Met with but once, near Camp Apache. The condition of this specimen, a female, indicated that it had bred in the vicinity.
* 69. *Phænopepla nitens* (Sw.). Shining Crested Flycatcher. "At Fort Whipple; a summer resident, and rather uncommon" (Coues). Permanent resident in the southern part of Territory. Very local in its distribution, being abundant at some points and entirely wanting in others.
* 70. *Myiodestes townsendi* (Aud.). Townsend's Solitaire. Apparently much more abundant as a resident bird of New Mexico than of Arizona. It occurs, however, over most of the latter Territory, and among the piñons of certain localities in the eastern part they have been found quite numerous.

LANIIDÆ. The Shrikes.

71. *Collurio borealis* (Vieill.). Great Northern Shrike. Visits the Territory rarely in winter. A single specimen was taken by Dr. Coues as far south as Fort Whipple.

* 72. *Collurio ludovicianus* (L.), var. *excubitoroides* (Sw.). White-rumped Shrike. Appears to be much more numerous in New Mexico than in Eastern Arizona, where I consider it to be very rare. "Resident about Tucson" (Bendire) "Rare, and probably resident at Fort Whipple" (Coues).

73. *Certhiola bahamensis* Reich. Bahama Creeper. Mentioned by Dr. Coues in his list, but I am not aware that it has actually been taken within the limits of the Territory. Has been found in Texas and also at Cape Saint Lucas.

TANAGRIDÆ. The Tanagers.

* 74. *Pyranga ludoviciana* (Wils.). Louisiana Tanager. Common summer resident in the pine woods of Eastern Arizona. "Rare at Fort Whipple" (Coues).
* 75. *Pyranga hepatica* Sw. Hepatic Tanager. Common; more so than the preceding species in Eastern Arizona from Camp Apache to the south. To some extent an inhabitant of the pines, but prefers the oak timber below. Summer resident.
* 76. *Pyranga æstiva* (Gm.), var. *cooperi* Ridgway. Cooper's Tanager. Apparently prefers the deciduous timber of the warm valleys in the southern part of the Territory. "Numerous along the Gila and San Pedro Rivers as a summer resident; Fort Mojave" (Cooper). "Perhaps at Fort Whipple" (Coues).

FRINGILLIDÆ. The Finches.

*77. *Hesperiphona vespertina* (Coop.). Evening Grosbeak. Breeds abundantly in the pine woods near Camp Apache. Met with at various other points in Eastern Arizona. "Winters about Tucson" (Bendire); and very probably in the extreme south of Territory generally. Not detected at Fort Whipple.

*78. *Carpodacus cassini* Bd. Cassin's Purple Finch. Of this species, the center of abundance appears to be farther to the north; it being common in Utah and Colorado. It probably is pretty well diffused over Arizona, though in the eastern part at least rare. "A common resident about Fort Whipple" (Coues).

*79. *Carpodacus frontalis* (Say). House Finch. Abundant. Resident. Numerous in many of the towns, where half-domesticated, and also inhabits the wilderness.

80. *Chrysomitris tristis* (L.). Goldfinch. "Summer resident; breeding at Tucson" (Bendire).

*81. *Chrysomitris psaltria.* Arkansas Finch. Perhaps the prevailing form through the more northern portions of the Territory. "Abundant; summer resident at Fort Whipple" (Coues).

*82. *Chrysomitris psaltria* (Say.), var. *arizonæ* Coues. Arizona Goldfinch. In summer replacing the former in the south. Probably a resident.

83. *Chrysomitris lawrenci* (Cass.). Lawrence's Goldfinch. I have never met with this species in the eastern part of the Territory, where very probably it is wanting. "Abundant at Fort Whipple where probably a resident" (Coues).

*84. *Chrysomitris pinus* (Wils.). Pine Finch. A not uncommon inhabitant of the mountains, breeding among the pines at an elevation of about 10,000 feet, at least as far south as Mount Graham.

85. *Loxia curvirostra* (L.), var. *americana* Wils. Red Crossbill. Specimens from the southern Rocky Mountains generally are referable to this form.

86. *Loxia curvirostra* (L.), var. *mexicana* Strickland. Mexican Crossbill. A series of Crossbills collected at Mount Graham in September are quite typical of this variety. Quite numerous here at this time, and quite likely are resident.

87. *Plectrophanes ornatus* Towns. Chestnut-collared Bunting. Very numerous throughout the plains of Eastern Arizona in fall, making their appearance the last of September. They occur, I think, only in winter.

88. *Plectrophanes maccowni* Lawr. McCown's Bunting. Like the preceding, occurring in large flocks in Eastern Arizona in fall and winter.

89. *Centronyx bairdi* (Aud.). Baird's Bunting. Occurs in great numbers over the plains of Eastern Arizona, where seen as early as August 16. I found no positive evidence that they breed within the Territory, though their condition suggested this.

*90. *Passerculus savanna* (Wils.), var *alaudinus* Bon. Western Savanna Sparrow. Abundant as a summer resident.

*91. *Poocætes gramineus* (Gm.), var. *confinis* Bd. Western Grass Finch. "Abundant summer resident; winters about Tucson" (Bendire), as probably the southern section generally.

*92. *Coturniculus passerinus* (Wils.), var. *perpallidus* Ridgway. Western Yellow-winged Sparrow. "Numerous on the grassy plains, south of the Gila River; Bill Williams's River" (Kennerly).

*93. *Chondestes grammaca* (Say). Lark Finch. Tolerably numerous in Eastern Arizona. At Fort Whipple, "chiefly spring and autumn migrant; many breed, and a few remain all winter" (Coues).

94. *Zonotrichia leucophrys* (Forster). White-crowned Sparrow. Not so numerous as the succeeding species, but found in considerable numbers in the eastern part of the Territory in the fall, where also they doubtless winter. All apparently go north to breed.

95. *Zonotrichia leucophrys* Forster, var. *intermedia* Ridgway. Western Ridgway's Sparrow. Visits the eastern part of the Territory in throngs in the fall; frequenting the undergrowth along the streams. Without doubt, many winter. Said by Dr. Coues to be resident (?).

96. *Junco hyemalis* (L.). Common Snowbird. "Rare and accidental" at Whipple; three specimens secured (Coues).

97. *Junco oregonus* (Towns.). Oregon Snowbird. An abundant fall and winter visitant.

98. *Junco cinereus* (Sw.), var. *caniceps* (Woodh.). Red-faced Snowbird. Given by Dr. Coues as a not very abundant winter resident at Fort Whipple. I am inclined to think, however, that his specimens are all referable to the var. *dorsalis*; *caniceps* being, however, a bird of Southern Colorado, and thus may in winter occur in Arizona.

*99. *Junco cinereus* (Sw.), var. *dorsalis* Bd. A very abundant species in summer in the mountains of Western New Mexico and the White Mountains of Arizona; presumably not reaching to the south of the Gila River, where replaced by the next species.

*100. *Junco cinereus* (Sw.). Mexican Snowbird. Very abundant at Mount Graham and in the Santa Rita Mountains, where it is probably resident.

*101. *Poospiza bilineata* (Cass.). Black-throated Sparrow. Common in the eastern part of Territory, becoming exceedingly numerous in the south, where resident. "Very abundant also in western parts" (Coues). Inhabits the open country and the brush-lined streams.

102. *Poospiza belli* (Cass.), var. *nevadensis* Ridgway. Artemisia Sparrow. Common in the fall in the eastern sections, where it winters. Frequents the sage-brush plains and the mequite thickets.

103. *Spizella monticola* (Gm.). Tree Sparrow. "Colorado Chiquito River in winter" (Kennerly); "also about Tucson in winter" (Bendire). Probably rare.

*104. *Spizella socialis* (Wils.), var. *arizonæ* Coues. Arizona Chipping Sparrow. Abundant over the Territory as a summer resident. "Winters about Tucson" (Bendire).

105. *Spizella pallida* (Sw.). Clay-colored Bunting. Given by Kennerly from Bill Williams's River; also from Tucson and Pima villages by Heermann. These citations have been referred to *S. breweri*, and with much likelihood; *pallida* does, however, occur in the southeastern part of Arizona, where, at old Camp Crittenden, we found it rather common in September. Probably winters.

*106. *Spizella breweri* (Cass.). Brewer's Sparrow. Through the eastern section very numerous in summer, and wintering in great numbers in the southeastern part. "Rare summer resident at Fort Whipple" (Coues).

*107. *Spizella atrigularis* (Caban.). Black-chinned Sparrow. "Rare; summer resident" at Fort Whipple (Coues). In the eastern parts it appears to be entirely wanting; was not seen by any of our parties nor by Captain Bendire during his residence near Tucson.

*108. *Melospiza melodia* (Wils.), var. *fallax* Bd. Western Song Sparrow. Rather common and generally distributed. Resident.

109. *Melospiza melodia* (Wils.), var. *heermanni* Bd. A single specimen was collected in Western Arizona by Mr. F. Bischoff, where it is probably but a straggler from the Sierra Nevadas.

110. *Melospiza lincolni* (Aud.). Lincoln's Finch. Exceedingly numerous in the eastern sections in the brush of many of the streams. Probably winters in the Gila Valley; none, it is thought, pass the summer there.

*111. *Peucæa æstivalis* (Licht.), var. *arizonæ* Ridgway. Arizona Sparrow. Abundant in several of the valleys in the southeast. Perhaps resident.

112. *Peucæa cassini* (Woodh.). Cassin's Sparrow. A very abundant inhabitant of the plains from the Gila River to the South. "Winters about Tucson" (Bendire).

*113. *Peucæa ruficeps* (Cass.), var. *boucardi* Sclat. Boucard's Sparrow. A common inhabitant of the submountainous sections from Camp Apache southward. Remains principally in rocky localities among the oaks, without venturing far into the pine region. Resident.

*114. *Peucæa carpalis* Coues. Rufous-winged Sparrow. Apparently restricted to the extreme southeastern portion, where it is an abundant resident. Confined to the low regions, where it is a frequenter of the brush and mesquite thickets.

115. *Passerella townsendi* (Aud.), var. *schistacea* Bd. A single specimen was captured a little south of Camp Apache in September of 1871. I can find no other instance of its occurrence.

116. *Calamospiza bicolor* (Towns.). White-winged Blackbird. A very abundant resident in Southeastern Arizona, congregating on the plains in immense flocks late in the fall. Not noticed about Fort Whipple by Dr. Coues.

117. *Euspiza americana* (Gmel.). Black-throated Bunting. Occurs in small numbers in Southeastern Arizona in fall.

*118 *Hedymeles melanocephalus* (Sw.). Black-headed Grosbeak. Abundant summer resident; generally distributed. Common in the pine woods near Camp Apache at elevation of 8,000 feet. Winters about Tucson.

*119. *Guiraca cœrulea* (L.). Blue Grosbeak. Common summer resident from Camp Apache south. Frequents the timbers of the streams of the low-lands. "A single specimen taken near Fort Whipple" (Coues).

*120. *Cyanospiza amœna* (Say). Lazuli Finch. Rather common in Eastern Arizona as a summer resident. Not abundant at Fort Whipple (Coues). "In winter about Tucson." (Bendire).

*121. *Cyanospiza ciris* (L.). Nonpareil. Present about Camp Bowie, and also in the Sonoita Valley as a summer resident. Found also by Captain Bendire near Tucson, where it breeds and also winters.

122. *Pyrrhuloxia sinuata* (Bp.). Texas Cardinal. Obtained by Mr. F. Bischoff in 1871. Found also at Camp Grant by Dr. E. Palmer. About Tucson it occurs in winter, and very probably may here be a resident.

*123. *Cardinalis virginianus* (Briss.), var. *igneus* Bd. Cape Cardinal. Occurs rather sparingly in Arizona in the southeast. "Breeds and is resident at Tucson" (Bendire).

*124. *Pipilo maculatus* (Sw.), var. *megalonyx* Bd. Very common; resident in the eastern section. "Very abundant; permanent resident at Fort Whipple" (Coues).

*125. *Pipilo fuscus* (Sw.), var. *mesoleucus* Bd. Cañon Bunting. Especially numerous in the southern and southeastern part of Territory, but also quite generally distributed.

*126. *Pipilo aberti* Bd. Abert's Towhee. In the valleys of the Gila and San Pedro Rivers; an abundant resident; also "resident about Tucson" (Bendire); also very abundant in valley of Colorado. "Common at Fort Mojave, and particularly so at Fort Yuma," (Coues).

* 127. *Pipilo chlorurus* (Towns.). Green-tailed Finch. In the eastern part of Territory a common summer resident. About "Tucson in winter" (Bendire). At "Fort Whipple only as a spring and fall migrant" (Coues).

ALAUDIDÆ. The Larks.

*128. *Eremophila alpestris* Boie, var. *chrysolæma* (Wagl.). This variety occurs as a resident, and in localities is quite common. In fall the numbers are increased by the arrival of immense numbers from the north; quite likely the northern *alpestris* occurs in winter.

ICTERIDÆ. The Orioles.

129. *Molothrus pecoris* (Gmel.). Cow Bunting. Generally distributed as a summer resident. "Winters abundantly in the Colorado Valley (Coues); also found at "Tucson in winter" (Bendire).

* 130. *Molothrus pecoris* (Gmel). var. *obscurus* (Cass.). Dwarf Cow Bunting. Occurring in the southern parts of Arizona, though seemingly not very common.

*131. *Agelæus phœniceus* (L.). Red-winged Blackbird. Common; resident in all suitable localities.

*132. *Xanthocephalus icterocephalus* (Bon.). Yellow-headed Blackbird. Very abundant in certain localities in the east, as the marshes of the San Pedro River, where resident. Generally diffused over the Territory in summer.

*133. *Sturnella magna* (L.), var. *neglecta* (Aud.). Western Meadow Lark. On account of a very general lack of favorable localities, not common. Resident.

*134. *Icterus parisorum* (Bon.). Scott's Oriole. Not uncommon in extreme southeastern part in summer. "Breeds about Tucson" (Bendire).

*135. *Icterus cucullatus* (Sw.). Hooded Oriole. Rather numerous in the region south of the Gila. Nests in the deciduous trees along the streams.

*136. *Icterus bullocki* (Sw.). Bullock's Oriole. Common summer sojourner. Breeds in the pine woods from about 10,000 feet to the deciduous trees of the lowest streams.

*137. *Scolecophagus cyanocephalus* (Wagl.). Brewer's Blackbird. Perhaps the most abundant, as it is the most generally distributed, of the family. Permanent resident.

CORVIDÆ. The Crows.

*138. *Corvus corax* (L.), var. *carnivorus* (Bartr.). American Raven. Very abundant everywhere. Permanent resident.

*139. *Corvus cryptoleucus* (Couch). White-necked Crow. Reported by Captain Bendire as much more common about Tucson than the Common Raven. He also found it breeding in the region. None of our parties met with it, nor has it been reported from other portions of the Territory.

140. *Corvus americanus* Aud. Common Crow. Numerous about Camp Apache in November, where it winters, and is said to remain in the adjoining mountains through the summer.

141. *Picicorvus columbianus*, (Wils.) Clarke's Crow. Found in the White Mountains in August, and I think it breeds there. "Abundant at Fort Whipple at irregular intervals during the winter months" (Coues).

*142. *Gymnokitta cyanocephala* Pr. Max. Maximilian's Jay. I found this species numerous in Western New Mexico, and presume it also occurs in Eastern Arizona, though none of our parties obtained specimens. Given by Dr. Coues as an abundant resident at Fort Whipple, breeding in the mountains.

*143. *Pica caudata* Flem., var. *hudsonica* Bon. Magpie. "Sparingly distributed throughout the Territory." (Coues).

*144. *Cyanura stelleri* (Gmel.), var. *macrolopha* Bd. A quite common, generally distributed, species. Resident In summer confined to the pine woods of the mountains, becoming more widely diffused in fall.

*145. *Cyanocitta floridana* (Bartr.), var *woodhousei* Bd. Woodhouse's Jay. Present in small numbers in the eastern part; in the northeast seemingly replaced to a great extent by the next species. "Resident, and exceedingly abundant, at Fort Whipple" (Coues).

*146. *Cyanocitta ultramarina* Bp., var. *arizonæ* Ridgway. Blue Jay. A common resident in the southeast, extending to the north nearly to Camp Apache. Shuns the deep forests, and lives in the oak-groves.

147. *Perisoreus canadensis* (L.), var. *capitalis* Bd. Rocky Mountain Gray Jay. Present in considerable numbers in the White Mountains, where I presume it is a permanent resident. I find no record of the species from elsewhere in Arizona, though the high mountains of the northern part probably furnish it a home.

TYRANNIDÆ. The Flycatchers.

*148. *Tyrannus verticalis* Say. Arkansas Flycatcher. Present in Eastern Arizona in small numbers, though generally replaced in this section by the following species. Breeds at Camp Grant, and even as far south as Tucson, where noted by Captain Bendire.

*149. *Tyrannus vociferans* Sw. Cassin's Flycatcher. Abundant and apparently diffused all over the Territory.

*150. *Myiarchus crinitus* (L.), var. *cinerascens* Lawr. Ash-throated Flycatcher. Common summer resident through the eastern section. "Resident about Tucson" (Bendire). "Common in summer at F rt Whipple." (Coues.)

*151. *Myiodynastes luteiventris* Sclat. Four specimens secured in the Santa Rita Mountains, Southeastern Arizona.

*152. *Sayornis nigricans* (Sw.) Black Pewee. Common and generally diffused over the Territory; resident in the more southern portions.

*153. *Sayornis sayus* (Bon.). Say's Pewee. Common. "Summer visitant at Fort Whipple" (Coues). Winters in the southern part of Territory generally.

*154. *Contopus borealis* (Sw. & Rich.). Olive-sided Flycatcher. Quite common in summer in the mountainous districts in the eastern portions. May winter in the south.

*155. *Contopus pertinax* Cab. Mexican Olive-sided Flycatcher. "Very rare; summer resident at Fort Whipple (Coues)." In the mountainous sections in the east and southeast, from Camp Apache down, quite common; one of the most so of its tribe; may perhaps winter.

*156. *Contopus virens* (L.), var. *richardsoni* (Sw.). Richardson's Pewee. Abundant summer resident over the Territory generally. "Resident about Tucson" (Bendire).

*157. *Empidonax traili* (Aud.). var. *pusillus* (Sw.). Least Flycatcher. More or less abundant throughout the Territory.

*158. *Empidonax flaviventris* Bd., var. *difficilis* Bd. Western Yellow-bellied Flycatcher. Not very common, though generally distributed in the mountainous sections, of which it is a summer resident.

*159. *Empidonax obscurus* (Sw.). Wright's Flycatcher. Of not uncommon occurrence as a summer resident Found both in the low valleys and higher up in the aspen-groves of the mountain-sides.

*160. *Empidonax hammondi* (De Vesey). Hammond's Flycatcher. Perhaps the most numerous of the small *Empidonaces* in Eastern Arizona, especially in the fall, when, in migrating, it descends from the high altitudes, where it spends the summer.

*161. *Mitrephorus fulvifrons* (Giraud), var. *pallascens* Coues. Yellow-headed Flycatcher. Occurring at intervals throughout Eastern Arizona, as far north, at least, as Camp Apache, but quite rare. An inhabitant of the mountains. "Rare at Fort Whipple." (Coues).

*162. *Pyrocephalus rubineus* Lawr., var. *mexicanus*, Sclat. Red Flycatcher. In Eastern Arizona, not reaching to the north of the Gila, in which valley and to the south it is of common occurrence, and in some of the river-bottoms abundant. "Resident about Tucson" (Bendire); and I am inclined to think along the southern border generally, extending on the Colorado to a higher latitude. "Camp Mojave" (Cooper).

ALCEDINIDÆ. The Kingfishers.

*163. *Ceryle alcyon* (L.). Kingfisher. A resident of the streams here and there, as these are stocked with fish.

164. *Ceryle americana* (Gmel.). Texas Kingfisher. "Observed at several points on the Colorado River between Forts Mojave and Yuma" (Coues).

CAPRIMULGIDÆ. The Goatsuckers.

*165. *Chordeiles popetue* (Vieill.), var. *henryi* Cass. Western Nighthawk. Abundant everywhere as a summer resident.

*166. *Chordeiles acutipennis* (Bodd.), var. *texensis* Lawr. Texas Nighthawk. In the east, as far north at least as the Gila Valley. In the Colorado Valley, as high as Camp Mojave, where noted by Dr. Cooper. A summer resident.

*167. *Antrostomus nuttalli* (Aud.). Nuttall's Whippoorwill. Very numerous everywhere as a summer sojourner. "Resident in the neighborhood of Tucson" (Bendire).

*168. *Acanthylis saxatilis* Woodh. Rocky Mountain Swift. Found in colonies here and there through the Territory, and in localities very numerous. Summer resident.

TROCHILIDÆ. The Hummingbirds.

169. *Stellula calliope* (Gould). Calliope Hummingbird. Very abundant in the White Mountains in August, and observed at various other points in Eastern Arizona.

*170. *Trochilus alexandri* Bourc. & Wils. Black-chinned Hummingbird. In Eastern Arizona, a summer resident, from Camp Apache south. Very numerous; in fact, the prevailing species of the family in the southeastern portion. Not reported from the western section.

171. *Calypte anna* (Less.). Anna Hummingbird. Tolerably numerous at Camp Grant in September. Perhaps only a migrant.

172. *Calypte costæ* (Bourc). Costa's Hummingbird. "Chiefly in southern and western part of the Territory" (Coues). "Bill William's River" (Kennerly). "Camp Mojave" (Cooper).

*173. *Selasphorus rufus* (Gmel.). Rufous-backed Hummer. "Summer resident at Fort Whipple; breeding abundantly" (Coues). Exceedingly numerous throughout the eastern section in fall. No evidence obtained of it breeding.

*174. *Selasphorus platycercus* (Sw.). Broad-tailed Hummer. Summer resident over all the Territory, remaining in the mountains through the summer.

*175. *Eugenes fulgens* (Sw.). Refulgent Hummer. More or less common in summer at Mount Graham. Perhaps an inhabitant of the mountains throughout Eastern Arizona.

*176. *Circe latrirotris* Bourc. Circe Hummer. Three specimens secured in the Santa Rita Mountains, near the border line, where presumably not an uncommon summer resident.

177. *Doricha enicura* Vieill. Slender Shear-tail Hummingbird. A single individual taken at Camp Bowie, August 8.

CUCULIDÆ. The Cuckoos.

*178. *Geococcyx californianus* (Less.). Chaparral Cock. "Rare at Fort Whipple" (Coues). In the east as far as the Gila River it is common, becoming less so to the north, but reaching into Southern Utah. Resident.

*179. *Coccygus americanus* (L.). Yellow-billed Cuckoo. Quite common in the southeast as a summer resident.

PICIDÆ. The Woodpeckers.

*180. *Picus villosus* L., var. *harrisi* Aud. Western Hairy Woodpecker. Perhaps the commonest as well as the most generally diffused of the group. Resident.

181. *Picus pubescens* L., var. *gairdneri* Aud. Gairdner's Woodpecker. One or two seen along the Gila River in October. Very rare.

*182. *Picus scalaris* Wagler. Ladder-backed Woodpecker. "Not a very common summer resident at Fort Whipple" (Coues). In the south and east as far up as the Gila River of common occurrence, chiefly in the river-bottoms and mesquite-thickets. "Resident about Tucson" (Bendire).

*183. *Picus stricklandi* Malh. Strickland's woodpecker. Numerous in the Santa Rita Mountains, where probably a resident.

*184. *Picoides americanus* Brehm, var. *dorsalis*, Bd. Western Banded Three-toed Woodpecker. Not uncommon in the White Mountains, Eastern Arizona, in October. Probably resident.

*185. *Sphyropicus varius* (L.), var. *nuchalis*, Bd. Red-naped Woodpecker. Numerous. Resident.

*186. *Sphyropicus thyroideus* (Cass.). Black-breasted Woodpecker. Not very common. Probably all through Arizona as an almost exclusive resident of the pine region.

*187. *Centurus uropygialis* Bd. Gila Woodpecker. In the southeast below the Gila River, common, and resident. "Rare, and perhaps accidental, at Fort Whipple" (Coues). Common in the Colorado Valley.

*188. *Melanerpes torquatus* (Wils.). Lewis Woodpecker. Rather common, and distributed over the Territory generally. In summer an inhabitant of the mountains. Resident.

*189. *Melanerpes formicivorus* (Sw.). California Woodpecker. "Exceedingly abundant at Fort Whipple" (Coues); as also at Apache and elsewhere to the south. Resident.

*190. *Colaptes mexicanus* Sw. Red-shafted Woodpecker. Rather common, frequenting all sorts of localities. Resident.

191. *Colaptes chrysoides* (Malh.). Cape Flicker. "Two pairs seen at Camp Mojave" (Cooper). "About Tucson in winter" (Bendire.).

STRIGIDÆ. The Owls.

*192. *Strix flammea* (L.). var. *pratincola* Bon. Barn Owl. Common; resident. "One of the most abundant owls of the Territory" (Coues). "Resident about Tucson" (Bendire).

*193. *Otus vulgaris* L., var. *wilsonianus* Less. Long-eared owl. Not uncommon. Resident.

194. *Otus* (*Brachyotus*) *brachyotus* (Gmel.). Short-eared owl. "Common throughout the Territory" (Coues). "Breeds about Tucson" (Bendire).

*195. *Syrnum occidentale* (Xantus). Western Barred Owl. Breeds and is resident about Tucson (Bendire).

*196. *Scops asio* (L.), var. *maccalli* Cass. Western Mottled Owl. Numerous in the eastern section. Resident.

197. *Scops flammeola* Licht. Flammulated Owlet. A single specimen secured by Dr. C. G. Newberry a short distance south of Camp Apache in September. Doubtless a resident.

198. *Bubo virginianus* (Gm.), var. *arcticus* Sw. Western Great Horned Owl. Common; resident.

*199. *Glaucidium passerinum* (L.), var. *californicum* Sclat. The Californian Pigmy Owl. Very numerous in the White Mountains; probably very generally distributed. Resident.

200. *Glaucidium ferrugineum* (Max.). Red-tailed Owl. "Resident about Tucson" (Bendire).

*201. *Micrathene whitneyi* (Coop.). Whitney's Owl. A single specimen taken by Dr. Cooper at Camp Mojave in April. Found breeding near Tucson by Captain Bendire.

*202. *Speotyto cunicularia* (Mol.), var. *hypugæa* (Bp.). Burrowing Owl. Quite numerous at many localities in Eastern Arizona. Resident.

FALCONIDÆ. The Falcons.

*203. *Falco lanarius* var. *polyagrus* Cass. American Lanner. Not common. "Colorado Chiquito River" (Kennerly). Observed on quite a number of occasions in Eastern Arizona. Resident.

*204. *Falco communis* Gmel., var. *anatum* Bon. Duck Hawk. Not uncommon in Northeastern Arizona. "Resident about Tucson" (Bendire).

*205. *Falco columbarius* L. Pigeon Hawk. "Common resident at Fort Whipple" (Coues). Occurs also in the eastern portion of Territory.

*206. *Falco femoralis* Temm. Aplomado Falcon. Southern Arizona, along the border; probably found in the east as high as the Gila Valley.

*207. *Falco sparverius* L. Sparrow Hawk. Numerous everywhere. Resident.

*208. *Polyborus tharus* (Moll.), var. *auduboni* (Cass.). Caracara Eagle. "Colorado River" (Kennerly); (Mollhausen). "Breeds about Tucson and is resident" (Bendire).

*209. *Pandion haliætus* L. var. *carolinensis* (Gmel.). Fish Hawk. Occurs on all the larger streams. Resident.

210. *Nauclerus forficatus* (L). Swallow-tailed Kite. Not personally met with by Dr. Coues, but given by him on the strength of reliable authority.

*211. *Circus cyaneus*, (L.), var. *hudsonius* (L.), Marsh Hawk. Numerous. Resident.

*212. *Nisus fuscus* (Gmel.). Sharp-shinned Hawk. Of common occurrence. Resident.

*213. *Nisus cooperi* (Bon.). Cooper's Hawk. Generally distributed and common. Resident.

*214. *Asturina nitida* Cass., var. *plagiata* (Schleg). Mexican Hawk. Rather common in the neighborhood of Tucson, where probably resident.

*215. *Urubutinga anthracina* Nitzsch. Observed by Captain Bendire in 1872, and eggs procured; seen twice by myself in Southeastern Arizona in 1874, where it seems to be not an uncommon species.

*216. *Parabuteo unicinctus* (Temm.). var. *harrisi*. (Aud.). Harris Buzzard. A single specimen procured by Kennerly and Mollhausen on the Colorado River.

*217. *Buteo swainsoni* Bon. Swainson's Hawk. A widely-distributed resident of the Territory, and numerous.

*218. *Buteo zonozercus* Sclater. Band-tailed Hawk. "A single specimen procured on the Gila River September 24, 1864" (Coues). Doubtless rarely straggles within our borders in summer.

*219. *Buteo lineatus* (Gmel.), var. *elegans* Cassin. Red-bellied Hawk. A single specimen taken on the Little Colorado by Dr. Kennerly.

*220. *Buteo borealis* (Gmel.), var. *calurus* Cassin. Western Redtail. Quite common. In summer mostly confined to the mountains. Resident.

Harlan's Hawk (*B. harlani*) is, with but little doubt, an inhabitant of the Territory; but though specimens have been obtained in New Mexico, none are as yet known from Arizona.

*221. *Archibuteo ferrugineus* (Licht.). California Squirrel Hawk. "Quite abundant about Fort Whipple, especially in winter" (Coues). Probably most numerous toward the northern border, though it has been found breeding near Tucson by Captain Bendire, where it is resident.

222. *Archibuteo lagopus* Brum., var. *sanctijohannis* (Penn.). Rough-legged Hawk.

"A single specimen taken at Fort Whipple in winter; rare" (Coues). Found about Tucson in winter by Captain Bendire.

223. *Aquila chrysaëtus* (L.), var. *canadensis* (Linn.). Golden Eagle. "Rare, but occasionally observed at different seasons, warranting the belief that it is a permanent resident of the mountains about Fort Whipple" (Cass.).

*224. *Haliætus leucocephalus* (Linn.). Bald Eagle. Present about Fort Whipple. Quite a number noted by us at different points in Eastern Arizona. Resident.

CATHARDIDÆ. The American Vultures.

*225. *Pseudogryphus californianus* (Shaw). Californian Vulture. "Resident in Southern Arizona" (Coues).

*226. *Rhinogryphus aura* (L.). Red-headed Vulture. Numerous, more particularly near the settlements. Resident in the southern portion.

COLUMBIDAE. The Pigeons.

*227. *Columba fasciata* (Say). Band-tailed Pigeon. Rather common; summer resident of the mountains in the eastern part, at least from Apache to the southward. "Rare about Fort Whipple" (Coues).

*228. *Melopelia leucoptera* (L.). White-winged Dove. Not uncommon as a summer resident of the extreme southern and southeastern portions. "Rare at Fort Whipple" (Coues).

*229. *Zenaidura carolinensis* (Bon.). Carolina Dove. Very abundant; summer resident; wintering in the extreme southern portion.

230. *Scardifella inca* (Bon.). Scaly Dove. A single individual taken at Tucson by Captain Bendire, where he considers it resident.

*231. *Chamæpelia passerina* (L.). Ground Dove. Very numerous in the extreme southeast part, about Camp Lowell; summer resident.

MELEAGRIDIDÆ. The Turkeys.

*232. *Meleagris gallopavo* (L.), Mexican Wild Turkey. Numerous in the White Mountains in Eastern Arizona as well as at other points. Permanent resident.

TETRAONIDÆ. The Grouse.

*233. *Canace obscurus* (Say). Dusky Grouse. A not uncommon resident of the White Mountains, which probably mark its extreme southern limits. The Sage Cock was met with by our parties quite far to the southward in Utah, and I have no doubt but that it reaches into Northern Arizona, though it has not yet been reported from the Territory.

PERDICIDÆ. The Partridges.

*234. *Lophortyx gambeli* Nutt. Gambel's Quail. Numerous, probably extending over all the Territory. Very abundant in the southeast. Resident.

*235. *Callipepla squamata* (Vigors). Scaled Partridge. In the east, as far north at least as the Gila; also, Lower Colorado. Not numerous. "Resident about Tucson" (Bendire).

*236. *Cyrtonyx massena* (Less.). Massena Partridge. Not numerous in the White Mountains and in the elevated regions to the south. Winters in the river-bottoms and warm valleys.

CHARADRIIDÆ. The Plovers.

*237. *Ægialitis vociferus* (L.). Killdeer Plover. Common; generally distributed near the water-courses. "Winters about Tucson" (Bendire).

238. *Ægialitis semipalmatus* (Bp.). Ringneck. Colorado River, September and October, 1865.

*239. *Ægialitis montanus* (Towns.). Rocky Mountain Plover. "Sparingly distributed throughout Arizona" (Coues).

RECURVIROSTRIDÆ. Stilts and Avocets.

240. *Recurvirostra americana* (Gm.). Avocet. "Seen in large flocks on the sand-bars of the Colorado" (Coues).

241. *Himantopus nigricollis* V. Stilt. "Common on the Colorado, in flocks with the preceding" (Coues).

PHALAROPHIDÆ. The Phalaropes.

242. *Steganopus wilsoni* (Sab.). Wilson's Phalarope. Numbers seen in Southeastern Arizona in August, migrating.

SCOLOPACIDÆ. The Snipes.

243. *Gallinago wilsoni* (Temm.). Wilson's Snipe. Not uncommon during the migrations.
244. *Macrorhamphus griseus* (Gm.). Red-breasted Snipe. "Sparingly distributed throughout the Territory" (Coues).
245. *Ereunetes pusillus* (L.). Semi-palmated Sandpiper. More or less common during the migrations.
246. *Tringa minutilla* V. Least Sandpiper. Same as preceding.
247. *Tringa bairdi* Coues. Baird's Sandpiper. Quite numerous during the fall at various points in Eastern Arizona; probably found over the Territory at large.
248. *Totanus semipalmatus* Gm. Willet. "Sparsely distributed throughout the Territory" (Coues).
249. *Totanus melanoleucus* Gm. Greater Yellowlegs. "Abundant on the Colorado" (Coues). A few occur here and there in Eastern Arizona. Its near relative, the Lesser Yellowlegs (*T. flavipes*), also without doubt occurs.
250. *Totanus solitarius* Wils. Solitary Tattler. Numerous in Eastern Arizona in fall.
251. *Tringoides macularius* (L.). Spotted Sandpiper. Common and general in its distribution.
252. *Actiturus bartramius* (Wils.). Field Plover. A single individual procured at Sulphur Spring, Southeastern Arizona, August 18.
253. *Numenius longirostris* Wils. Long-billed Curlew. "A single specimen taken in August, 1864, at Foot Whipple" (Coues).

TANTALIDÆ. The Ibises.

*254. *Tantalus loculator* L. Wood Ibis. "Very common on the Colorado, at least as high as Fort Mojave, but especially abundant on the lower portions of this river and of the Gila" (Coues).
255. *Ibis thalassinus* Ridgway. A single individual taken at Camp Lowell by Dr. Rothrock.

ARDEIDÆ. The Herons.

256. *Ardea herodias* L. Great Blue Heron. Found on all the streams of the Territory.
257. *Ardea egretta* Gm. Great White Egret. "Abundant along the Colorado" (Coues). Numerous on the San Pedro.
258. *Ardea candidissima* Jacquin. Little White Egret. "Very abundant throughout the valley of the Colorado" (Coues).
259. *Ardea virescens* L. Green Heron. Common on the streams generally.
260. *Nyctiardea grisea* (L.), var. *nævia* (Bodd.). Night Heron. Occurring here and there throughout the Territory.
261. *Botaurus minor* Gm. Bittern. Generally distributed.
262. *Ardetta exilis* Gm. Least Bittern. "Generally distributed on the streams and *sienegas* of the Territory; common on the Colorado" (Coues).

GRUIDÆ. The Cranes.

263. *Grus canadensis* (L.). Sandhill Crane. Numerous on the large streams.

RALLIDÆ. The Rails.

264. *Rallus virginianus* L. Virginia Rail. Several seen in the eastern part of Arizona. Probably occurring regularly in all places suited to its habits.
265. *Porzana carolina* (L.). Carolina Rail. One seen near Camp Apache by Dr. C. G. Newberry. "Colorado River" (A. Schott).
266. *Fulica americana* Gm. Coot. Abundant on many of the streams and *sienegas*.

ANATIDÆ. The Ducks.

267. *Cygnus americanus* Sharpless. Whistling Swan. "Colorado River" (Coues). "Fort Mojave" (Cooper).
268. *Anser albifrons* Gm., var. *gambeli* (Hartl.). White-fronted Goose. "Abundant on the Colorado" (Coues).
269. *Anser hyperboreus* Pall. Snow Goose. "Common on the Colorado" (Coues).
270. *Branta canadensis* (L.). Canada Goose. "Colorado River" (Coues).
271. *Branta canadensis* (L.), var. *hutchingsi*. Hutchins's Goose. One of the most abundant geese of the Colorado Valley.
272. *Dendrocygna fulva* (Gm.). Fulvous Tree Duck. "A pair taken in November about twenty miles from Fort Whipple" (Coues).
273. *Anas boschas* L. Mallard. Abundant.

274. *Dafila acuta* (L.). Pin Tail. Numerous.
275. *Chaulelasmus streperus* (L.). Gadwall. *Mareca americana* (Gm.). Widgeon. *Spatula clypeata* (L.). Shoveler. "All three found on the Colorado River" (Coues).
276. *Querquedula carolinensis* (Gm.). Green-winged Teal. *Querquedula discors* (L.). Blue-winged Teal. Both species abound on all the water-courses.
277. *Querquedula cyanoptera* (V.). Red-breasted Teal. "Found on the Colorado and San Francisco Rivers in October" (Coues).

PELECANIDÆ. The Pelicans.

278. *Pelecanus trachyrynchus* Lath. White Pelican. "Abundant on the Gila and Colorado Rivers" (Coues).

PHALACROCRACIDÆ. The Cormorants.

279. *Graculus dilophus* (Sw.). Double-crested Cormorant. "Gulf of California and Lower California" (Cooper).

LARIDÆ. The Gulls.

280. *Larus delawarensis* Ord. Ring-billed Gull. Seen by Dr. Coues on the Colorado in fall.
281. *Larus atricilla* L. Laughing Gull. "Colorado River, particularly its lower portion" (Coues).
282. *Larus philadelphia* (Ord). Bonaparte's Gull. "Very abundant on the Colorado" (Coues).
283. *Sterna forsteri* Nutt. Forster's Tern. "Occurs on the Colorado" (Coues).
284. *Sterna hirundo* L. Common Tern. A single specimen taken on the San Pedro River in October.
285. *Hydrochelidon fissipes* L. Black Tern. Numerous at Sulphur Spring in "Colorado River" (Coues). Mojave River (Cooper).

COLYMBIDÆ. The Loons.

286. *Colymbus torquatus* Brunn. Loon. "Winter resident on the Colorado River; common" (Coues).
287. *Colymbus arcticus* L., var. *pacificus* (Law.). Pacific Diver.

PODICIPIDÆ. The Grebes.

288. *Podiceps occidentalis* Lawr. Western Grebe. Gila River in November, one specimen.
289. *Podiceps cornutus* (Gm.). Horned Grebe. "Colorado River" (Coues).
290. *Podiceps auritus* (L.), var. *californicus* (Heerm.). American Eared Grebe. "Colorado River; abundant." (Coues).
291. *Podilymbus podiceps* (L.). Pied-billed Grebe. "Colorado River; abundant" (Coues).

APPENDIX J.

ETHNOLOGY, PHILOLOGY, AND RUINS.

1. Report on the remains of population observed on and near the Eocene Plateau of Northwestern New Mexico.
2. Report on the ruins of New Mexico.
3. Report on certain ruins visited in New Mexico.
4. Report on the Pueblo languages of New Mexico: their affinity to each other and to the languages of other Indian tribes.

J 1.

REPORT ON THE REMAINS OF POPULATION OBSERVED ON AND NEAR THE EOCENE PLATEAU OF NORTHWESTERN NEW MEXICO. BY PROF. E. D. COPE.

HADDONFIELD, N. J., *June* 30, 1875.

SIR: While encamped on the Gallinas Creek at the point where it issues from the Sierra Madre, with the party detailed by you for purposes of geological and paleontological exploration, I occupied intervals of time in the examination of the traces left by the former inhabitants of this portion of New Mexico. Had time permitted, the exploration of these remains might have been much extended, but under the circumstances a mere beginning was made. The observations show that the country of the Gallinas and the Eocene Plateau to the west of it were once occupied by a numerous population. Now there are no human residents in the region, and it is only traversed

by bands of the Apache, Navajo, and Ute tribes of Indians. The indications of this ancient population consist of ruined buildings, pottery, flint implements, and human bones. Broken vessels of baked clay are frequently found, and the fragments occur in all kinds of situations throughout the country. They are usually most easily discovered on the slopes of the hills and hog-backs of Cretaceous and Tertiary age, and, where abundant, generally lead to a ruined building standing on the elevation above.

The hog-back ridges, described in geological report, (App. G 1,) extend in a general north and south direction on the western side of the Sierra Madre, south of Tierra Amarilla. They vary from two to four in number, and stand at distances of from half a mile to three miles from the mountain range. The Gallinas Creek flows between two of them near their southern extremities for perhaps fifteen miles. At one point the hog-backs of Cretaceous, Nos. 3 and 4, approach near together, and the creek flows near to the foot of the eastern front, or escarpment, of No. 3. The rock of this ledge is a hard sandstone, and resists erosion; hence its outcrop forms continuous sharp ridges, with distant interruptions, which are termed by the Mexicans the cuchillas, or cristones. The hog-back of No. 4, being composed of softer material, is worn by erosion into a succession of subconical eminences.

My attention was first called to the archæology of the region by observing that the conic hills just mentioned appeared to be in many instances crowned with stone structures, which, on examination, proved to be ruined buildings. These are round or square, with rounded angles, and from 15 to 25 feet in diameter. The walls are 2 and 3 feet in diameter, and composed of stones of moderate size, which have been roughly dressed, or built without dressing, into solid but not very closely-fitting masonry. The walls remaining measure from 10 feet high downward. The floor inside is basin-shaped, or like a shallow bird-nest, and frequently supports a growth of sage-brush (*Artemisia*) of the same size and character as that growing on the plains below, and other shrubs. Sometimes they contain piñon trees (*Pinus cembroides*) of 1 and 2 feet in diameter, which is the average and full size to which they grow on the adjacent ridges and plateaus. Within and about them fragments of pottery abound, while flint implements are less common. As these are similar in all the localities examined, they will be subsequently described. A building more or less exactly agreeing with this description was found on the summit of every hill of a conical form in the vicinity. Their form is probably due to the shape of the hill, as they were differently built on the level hog-backs. None of the circular buildings were found to be divided, nor were any traces of such buildings observed on lower ground.

The hog-back of Cretaceous No. 3 is the locality in question, only one or two hundred yards distant from the eastern of the hills just described, from which it is separated stratigraphically by a bed of lignite. At some points this stratum has been removed by atmospheric erosion, leaving a ravine between the hog-backs. Near the middle of a section of the hog-back No. 3 a portion of this formation remains, forming a narrow causeway connecting it with the ridge just behind it. The eastern face is a perpendicular wall of sandstone rock of about 300 feet in elevation; the western face is the true surface of the stratum, which here dips about 45° to 55° west by north. The top of the ridge varies in width from 4 to 11 feet.

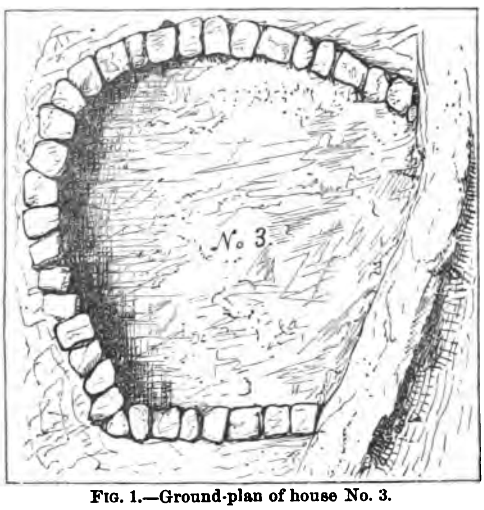


FIG. 1.—Ground-plan of house No. 3.

In riding past the foot of the precipice, I observed what appeared to be stone walls crowning its summit. Examination of the ridge disclosed the fact that a village form-

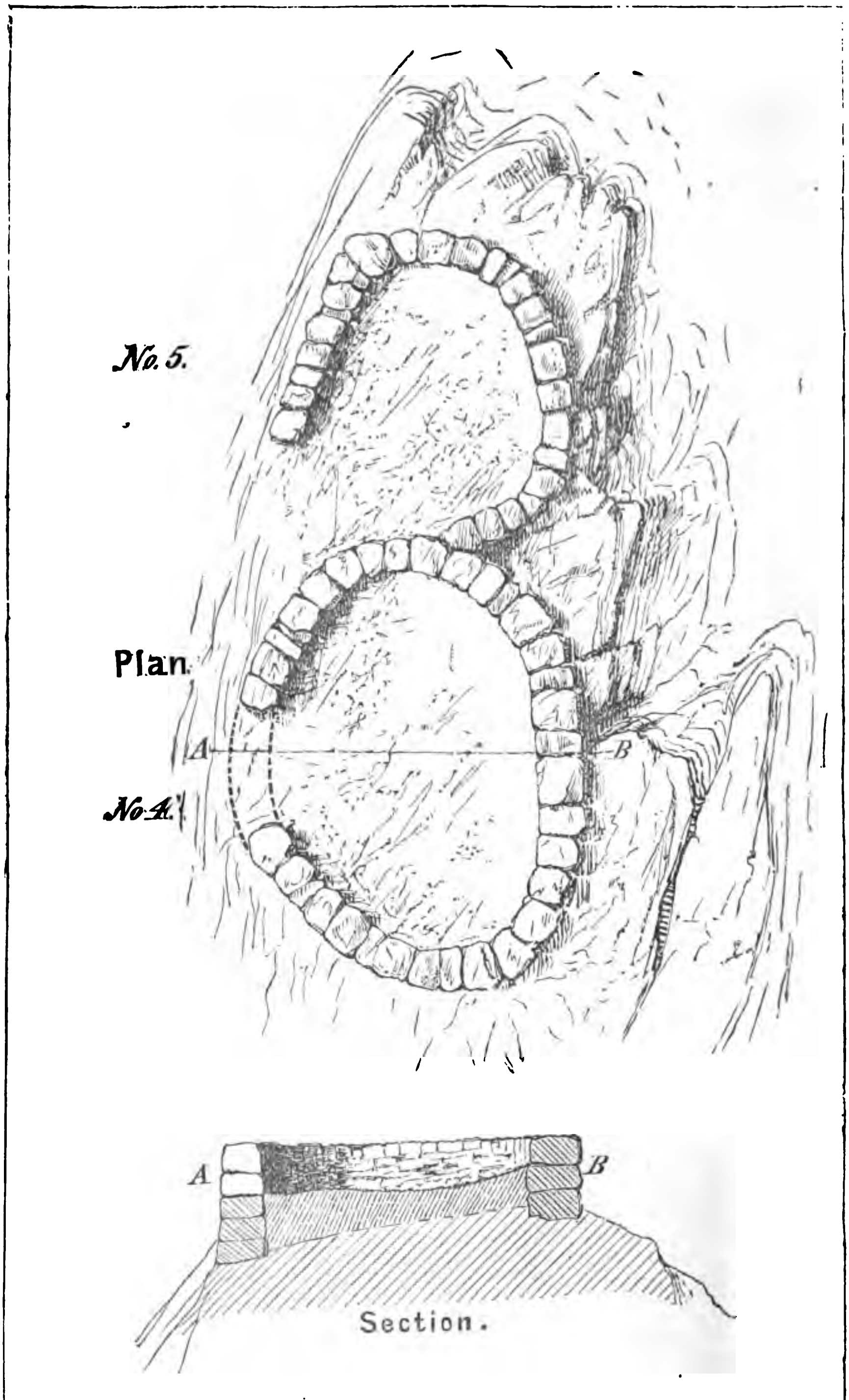


FIG. 2.—Ground-plan of houses Nos. 4 and 5 and profile of No. 4.

ing a single line of thirty houses, extended along its narrow crest, twenty-two of them being south of the causeway, and eight north of it. The most southern in situation is at some distance from the southern extremity of the hog-back. I selected it as a posi-

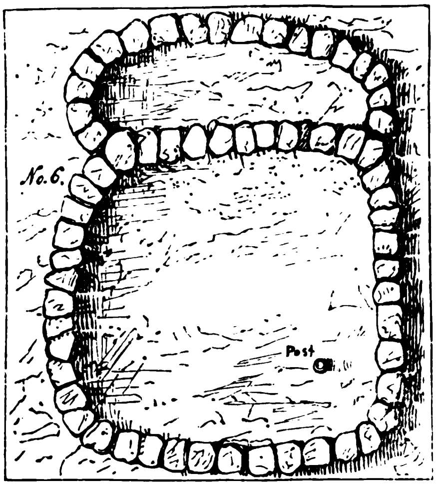


FIG. 3.—Ground-plan of house No. 6.

tion from which to sketch the country to the south and west. (See Geological Report, appendix G 1.) It is built on the western slope of the rock, a wall of 12 feet in height supporting it on that side, while the narrow ledge forming the sum-

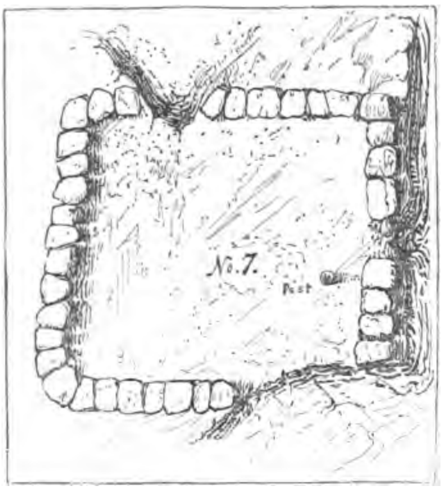


FIG. 4.—Ground-plan of house No. 7.

mit of the ridge is its back wall. It is square, 3.355 meters on a side, and has a floor leveled with earth and stones. Two stout cedar-posts probably once supported the roof; their stumps remain, well cracked and weathered. Bushes of sage, similar in size to that of the surrounding plain, are growing within the walls. The second house is immediately adjoining, and is surrounded by an independent wall, that on the lower side of the ridge being still 12 feet in height. The length of the inclosure is 4.69 meters, and the width 2.68 meters; full sized scrub-oak and sage-brush are growing in it. The stumps of two cedar posts remain, one 5, the other 8 inches in diameter. The third house adjoins No. 2, but is surrounded by a distinct wall, except at the back or side next the precipice, where a ledge of rock completes the inclosure. The latter is 4.02 meters long; it contains a scrub-oak of 3 inches diameter, which is an average size for the tree.

Beyond these ruins is an interval of 69 meters, where the summit of the rock is narrow and smooth, and the dip on the west side 55°. The walls of an oval building follow, (Fig. 1,) which inclose a space of 4.69 meters. They are 2 to 2½ feet in thickness, and stand 8 feet high on the western side; the eastern wall stands on the sheer edge of the precipice. A building adjoins, with the dividing-wall common to the preceding house. Its east and west walls stand on parallel ledges of the sandstone strata, whose strike does not exactly coincide with the axis of the hog-back. Diameter of this inclosure 5.37 meters. A space of 15.4 meters follows, with precipices on both sides, when we reach house No. 6. The eastern wall stands 5 feet high on the summit of the precipice, from which a stone might be dropped to the ground, perhaps 350 feet below. Only 8 feet of the western wall remained at the time of my examination. The inclosure is 6.04 meters long, and not quite so wide, and is divided transversely by a wall, which cuts off less than one-third the length of the apartment. In one of the opposite corners of the larger room is the stump of a cedar-post 5 inches in diameter. This house can only be reached by climbing over narrow ledges and steep faces of rock. House No. 7 follows an interval of 42.30 meters. Its foundation-wall incloses an irregular square space 4.70 meters long and 3.69 meters wide; it is 11 feet high on the western side, and very regularly built and well preserved; on the east side it is 8 feet high, and is interrupted by a door-way of regular form. From this a narrow fissure offers a precarious hold for descent for a considerable distance down the face of the precipice, but whether passable to the bottom I could not ascertain.

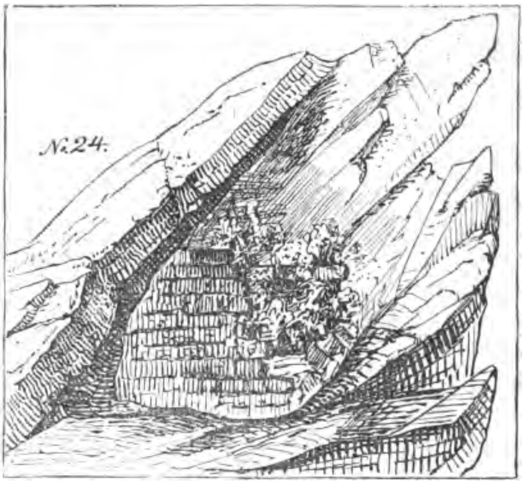


FIG. 5.—View of house No. 24.

The crest of the ridge is without ruins for 52.34 meters farther; then a building follows whose inclosed space is an irregular circle of 4.70 meters diameter. A transverse summit-ledge forms its southern wall, but the remaining portion is remarkably massive, measuring 3 feet in thickness. Its western wall is 12 feet high, and contains many huge stones, which four or five men could not lift unaided by machinery. Several scrub-oaks of 3 inches in diameter grow in this chamber, and stumps of the cedar-posts that supported the roof remain. Here follows a row of ten similar ruined houses, measuring from 3.35 to 6.24 meters in length. Of this number, thirteen are remarkable for containing a scrub-oak of 13 inches in diameter, the largest that I have seen in the country, and the species is an abundant one. In No. 14, the remaining western wall is 15 feet in height. There was a good deal of pottery lying on the western slope of the rock, but of flint implements and chips I found but few. All of these ruins contain full-grown sage-bushes. No. 18 is the largest ruin; the length of its inclosure is 8.62 meters, and the width 6.71 meters; its west wall is 6 feet high; the floor is overgrown with sage of the largest size. This building stood 51 meters from No. 17; 12.80 meters northward the ridge descends slightly to the level of the causeway already mentioned. Here are five more ruined buildings of the same average size as the others, interrupted by but one short interval.

From this depression, that part of the hog-back which is north of the causeway rises abruptly in a perpendicular face. It is composed principally of two layers of the sandstone, dipping at 45° W., which are separated by a deep cavity from a point 15 feet from the base upward. This niche has been appropriated for a habitation, for it is walled to a height of 8 feet from its base. The foot of the wall is quite inaccessible,

but by climbing round the eastern face of the precipice a ledge is found at the base of the projecting stratum, which forms the east wall of the inclosure. This was scaled by means of a staircase of stones, a number of which were in position at the time of my visit. The remaining portion of the hog-back is elevated and smooth, and the foundation-stones only of several houses remain. One of these contains two stout posts, of which four feet remain above ground; the last house is near the end of the ridge, and is bounded by a wall of 10 feet in height, which forms its western side.

The walls of these houses are built with a mortar of mud, mixed in many cases at least with ashes, judging from the abundant specks of charcoal which it contains. It is not of good quality, and has weathered much from between the stones. I could not discover any indications of the destruction of the houses by fire either on the stones or the cedar-posts. The latter doubtless lost by weathering such indications had they existed, and the combustion of the entire contents of such small domiciles could have effected their stone walls but little. I found no remains of bones of animals or men about them.

This town I called Cristone. The same hog-back recommences a little more than a mile to the north, rising to a greater elevation, say 600 or 700 feet above the valley. The east side is perpendicular, while the dip of the west side is 60°, and sometimes even a higher angle. On this almost inaccessible crest I could see from the valley the walls of ruined stone buildings, such as I have just described; but unfortunately my limited time prevented me from making a detailed examination of them. In the opposite direction I observed a similar ruin on an outlying hill adjacent to the southern portion of the southern hog-back. This one is of larger size than any of the others, but I was unable to visit it.

The position of these buildings is susceptible of the same explanation as that of the still inhabited Moqui villages of Arizona, so interestingly described by Lieutenant Ives in his report on his survey of the Rio Colorado of the West, and of the route from its cañon to Santa Fé. They were doubtless perched on these high eminences for purposes of defense, and they were conveniently located near a perennial stream, which permitted them to carry on a system of agriculture no doubt similar to that now practiced by the Moquis. The inhabitants of Cristone felt, however, one disadvantage not known to the Moquis; they were, so far as present indications go, without water on their elevated rocks, but were dependent for their supply on the Gallinas Creek. I found no indication of cisterns which should furnish such supply in time of siege, although they doubtless could depend for a considerable length of time on rain-water, which they caught and preserved in the many vessels of pottery, whose fragments are now so numerous about the ruins.

At this point the bluffs of the Eocene bad-lands are from nine to ten miles from the Gallinas Creek. Here also the slopes are in places covered with broken pottery, and on the summits of some of the less elevated buttes circular walls indicate the former existence of buildings similar to those crowning the conical hills along the creek. The latter contains the nearest water to these ruins. In other localities ruined stone buildings occupy the flat summits of mesa hills of the bad-lands, often in very elevated and well-defended positions. It was a common observation that the erosion of the faces of these bluffs had undermined the foundations of the houses, so that their wall-stones, with the posts, were mingled with the pottery on the talus below. At one point foundation-walls stand on an isthmus, connecting a butte with the mesa, of which a width of 20 feet remains, but which is furrowed with water-channels. Here Eocene fossils and crockery, including a narrow-necked jug, were confusedly mixed together. At another point the narrow summit of a butte, of nearly 200 feet elevation, is covered with remnants of stone buildings which extend for a length of 200 yards. The greater part of them had been undermined, and the stones were lying in quantities on the talus at the time of my visit. At one end of the line the bases of two rectangular walls, perhaps of towers, appeared to have been placed as supports to the terrace. Very dry cedar-posts occur among the ruins, and three such, standing upright on the summit of the butte, mark a spot as yet unaffected by the disintegration of the cliff. In another portion of the ruins a row of large earthenware pots was found buried in the earth. The slow movement of the marl-changes of level had already fractured them. At another locality I took from a confused mass of ruins the temporal bones of an adult person, the ilium of a child, ribs, and other bones. At a remote portion of the ruins, on a remaining ledge, I found a square inclosure formed of stones set on edge, three stones forming each half of the inclosure. I excavated this for the depth of a foot without finding any indication of its use. In some of these localities chips, arrow-heads, and thin knives of chalcedony and white flint were found, with similar implements of obsidian. The obsidian knives are similar to those which I have seen as commonly found in Mexico.

At the head of the Cañon cito de las Vegas there are numerous low hills of the Eocene marl, covered with piñon forests of adult trees. On a low slope of one of these I found the burial place of one of the inhabitants, as indicated by his bones, and trinkets doubtless buried with him. His tibia was a marked example of the platycnemic

type. Close to them were some good quartz-crystals, of course intruders in such a formation, a piece of *chalchuitl*, an apparently transported scaphite, some implements of obsidian, flint, &c., and a single perfect lower molar of a large mammal of the genus *Bathmodon*, attached to a piece of the jaw, which looked as though the ancient proprietor had not been ignorant of the peculiar products of the neighboring bluffs.

In traversing the high and dry Eocene plateau west of the bad-land bluffs, I noticed the occurrence of crockery on the denuded hills for a distance of many miles. Some of these localities are fifteen and twenty miles from the edge of the plateau, and at least twenty-five miles from the Gallinas Creek, the nearest permanent water. In some of these localities the summits of the hills had been eroded to a narrow keel, destroying the foundations of the former buildings. In no locality did I observe inscriptions on the rocks or other objects, which were, probably, the work of the builders of these stone towns; but I give a copy of figures which I found on the side of a ravine near to Abiquin, on the river Chama. They are cut in Jurassic sandstone of medium hardness, and are quite worn and overgrown with the small lichen which is abundant on the face of the rock. I know nothing respecting their origin.

It is evident that the region of the Gallinas was once as thickly inhabited as are now the more densely populated portions of the Eastern States. The number of buildings in a square mile of that region is equal to if not greater than the number now existing in the more densely populated rural districts of Pennsylvania and New Jersey. Whether this is the case to the south and west, I do not know, as I was unable to devote the necessary time to the examination. I found, however, that without investigation, it is very easy to pass the ruins by unnoticed, since their elevated positions, ruinous condition, and concealment by vegetation, render them almost invisible to the passing traveler. In general, I may say that the number of ruins I found was in direct proportion to the attention I gave the matter; where I looked for them I invariably found them in suitable situations.

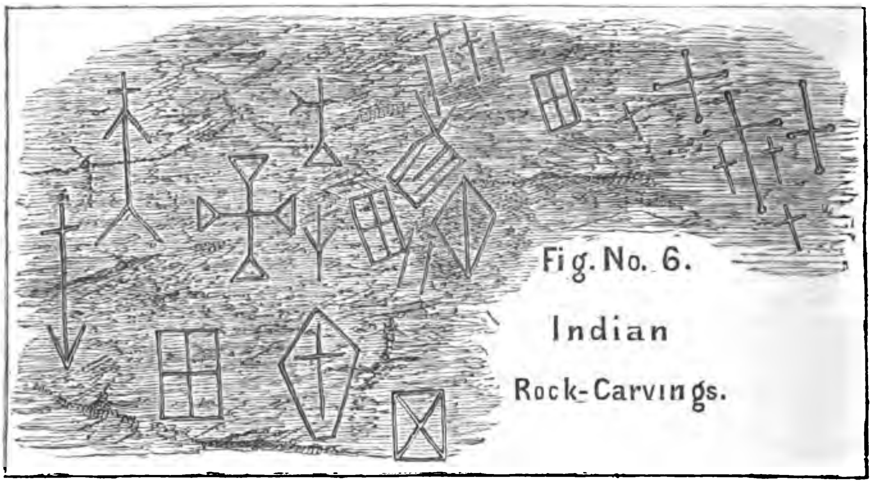


Fig. No. 6. Indian Rock-Carvings.

Perhaps the most remarkable fact in connection with these ruins is the remoteness of a large proportion of them from water. They occur everywhere in the bad lands to a distance of twenty-five miles from any terrestrial source of supply. The climatic character of the country there has either undergone material change, or the mode of securing and preserving a supply of water employed by these people differed from any known to us at the present time. I found no traces of cisterns, and the only water-holders observed were the earthenware pots buried in the ground, which did not exceed eighteen inches in diameter. There is, however, no doubt that these people manufactured great numbers of these narrow-necked globular vessels, whose principal use must have been the holding of fluids, and chiefly of water. Nevertheless, it is scarcely conceivable that the inhabitants of the houses now so remote from water could have subsisted under the present conditions. Professor Newberry (Ives' Report) is of the opinion that a diminution in the amount of rain-fall over this region has taken place at no very remote period in the past, and cites the death of forests of pine-trees which still stand as probably due to increasing drought. It is, of course, evident that erosive agencies were once much more active in this region than at present, as the numerous and vast cañons testify, but that any change sufficient to affect this process should have occurred in the human period, seems highly improbable. In other words, the

process of cutting cañons of such depth in rocks of such hardness is so slow that its early stages, which were associated with a different distribution of surface-water supply, must have far antedated the human period.

Nevertheless if we yield to the supposition that during the period of residence of the ancient inhabitants the water-supply from rains was greater than now, what evidence do we possess which bears on the age of that period? There is no difference between the vegetation found growing in these buildings and that of the surrounding hills and valleys; the pines, oaks, and sage-brush are of the same size, and to all appearances of the same age. I should suppose them to be contemporary in every respect. In the next place, the bad lands have undergone a definite amount of atmospheric erosion since the occupancy of the houses which stand on their summits. The rate of this erosion, under present atmospheric influences, is undoubtedly very slow. The only means which suggested itself at the time as available for estimating this rate was the calculation of the age of pine-trees which grow near the base of the bluffs. These have of course attained their present size since the removal of the front of the stratum from the position which the trees now occupy, so that the age of the latter represents at least the time required for the erosion to have removed the bluff to its present position, but how much time elapsed between the uncovering of the position now occupied by the tree and its germination, there is of course no means of ascertaining. My assistant, an educated and exact man, counted the rings in a cut he made into the side of a piñon (*Pinus cembroides*) which stood at a distance of 40 feet from a bluff, not far from a locality of ruins. In a quarter of an inch of solid wood he found sixteen concentric layers, or 64 in an inch. The tree was fully twenty inches in diameter, which gives 640 annual growths. The piñon is a small species, hence the closeness of the rings in an old tree.

At present it is only possible to speculate on the history of the builders of these houses, and the date of their extinction. The tribes of Indians at present inhabiting the region at irregular intervals, can give no account of them. But it is not necessary to suppose that the ruin of this population occurred at a very remote past. On the Rio Chaco, not more than thirty miles from the Alto del Utah, are the ruins of the seven cities of Cebolla, the largest of which is called Hunyo Pavie. These have been described by General Simpson, (Report of Lieut. James H. Simpson of an expedition in the Navajo country in 1849, Ex. Doc. 1st sess. 31st Congress,) who shows that each of the towns consisted of a huge communal house, which would have accommodated from fifteen hundred to three thousand persons. Their character appears to have been similar to that of the existing Moqui villages.

The "cities of Cebolla" were visited by the marauding expedition of Coronado in 1540, which captured them to add to the viceroyalty of Mexico. In his letter to Mendoza, the viceroy, Coronado states that the inhabitants on the fourth day after the capture "set in order all their goods and substances, their women and children, and fled to the hills, leaving their town as it were abandoned, wherein remained very few of them."

There can be no doubt that the Eocene plateau and hog-backs of the Gallinas offer hills of the greatest elevation in the entire region, and it is highly probable, if the account quoted be correct, that some at least of the exiled Cebollians found a refuge in this region, and may have been the builders of Cristone. This would place the age of the ruins described at three hundred and thirty-five years. Of course it is possible that they represent villages contemporary with and tributary to the seven cities.

The inhabitants of the rock-houses of the Gallinas necessarily abandoned the communal type of building generally employed by their race, and appear only to have considered the capacities of their dwellings for defense. Yet the perils of life in Cristone due to the location alone, must have been considerable. Infant sports must have been restricted to within doors, and cool heads were requisite in adults to avoid the fatal consequences of a slip or fall. Intoxication must have been rare in Cristone. There is no trace of metal in any of the ruins of the Gallinas, and it is evident that the inhabitants were acquainted with the use of stone implements only, as was the case with the builders of the cities of Central America. I have already alluded to their pottery. It is usually of a bluish-ash color, but is occasionally black, brown, and more rarely red. It is never glazed, but the more common kind is nicely smoothed so as to reflect a little light. This pottery is ornamented with figures in black paint, which are in lines decussating or at right angles, or closing triangular or square spaces. Sometimes colored and uncolored angular areas form a checker-board pattern. The coarser kinds exhibit sculpture of the clay instead of painting. The surface is thrown into lines of alternating projections and pits by the use of an obtuse stick, or the finger-nail, or it is thrown into imbricating layers by cutting obliquely with a sharp flint-knife. Thus the patterns of the ornamentation were varied according to the taste of the manufacturers, although the facilities at their disposal were few.

With these observations, I close this sketch of a glimpse at one locality of the earliest civilization known on the American continent.

Respectfully submitted. E. D. COPE.

Lieut. GEO. M. WHEELER, *Corps of Engineers*.

J 2.

REPORT ON THE RUINS OF NEW MEXICO, BY DR. OSCAR LOEW.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS
WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., April 24, 1875.

Among the few regions that were found, on the discovery of this continent, inhabited by civilized people, New Mexico, no doubt, occupies a leading place. The first notices of these people were published by Cabeza de Vaca, (1536,) who, during his adventurous and most remarkable wanderings from Florida to the Gulf of California, traversed New Mexico from east to west. All the Spanish records, though sometimes very untrustworthy, agree in one point—the large number of inhabited towns. If the statements of the Spanish writers are founded on truth, the number of these towns was ten times that of the present pueblos, or Indian towns, while, by a close examination, we would arrive at a number about four times as great. Some Spanish writers estimated the whole pueblo population at about 50,000; others, however, that of a single province at 25,000. As a proof of Spanish exaggeration, however, I may mention Castaneda's description of Acoma, a town which, according to his estimate, was inhabited by 5,000 persons, and was built in three parallel rows of houses. Now, I have visited this town and found the three rows of houses still existing; they extend from one side of a steep precipice to the other end of the rock, and occupy the entire width of the precipitous bluffs, about 200 feet above the plain. But these rows, which could never have been any longer, could not have held more than about 1,000 people. At present the population of the town is 800. Still it is an undeniable fact that New Mexico had a much greater Indian population formerly than now—a fact clear to any one on viewing the numerous ruins. If asked how this reduction was brought about we can give but three reasons, viz, 1st, the change of climate that prompted emigration from certain parts of the country; 2d, the wars with the Spaniards, whereby wholesale slaughter was often ordered by the Spanish generals; and, 3d, a gradual mixture of Spanish and Indian blood, whereby the Indians lost their customs and language; Abiquiu, for instance, is such a town, where the characteristic Indian type still prevails, although they call themselves Mexicans. Such Mexicanized towns often received the name of a saint. Not only these, however, but also the names of the unmixed pueblos were in a number of cases abolished and those of saints substituted through the pious zeal of Spanish priests.

Looking over the names of towns mentioned in the Spanish reports, we find ourselves in many cases unable to locate them, not even ruins being found where, from the description, we would suppose they existed. But not only is this the case with the towns; we often encounter the same difficulty with the provinces, the Spanish using the name of each town in the province in turn to name the latter; often the province is named after the valley of rivers or after mountains. The truth is, the pueblos had no provinces, each town having its own government: the *maire* being elected every year. But if we would distinguish provincec, the language alone should be used as a criterion.

Marata, Acus, Totonteal, Acha, Tabasas, Sumas, Jumanes, Conchos, Passaguates, Jerez, Piros are names of provinces which to locate is rather difficult; the most of them were in Southern New Mexico. At present, there is no pueblo existing there, except perhaps, Isleta below El Paso, which now belongs to Texas. But ruins are found here and there on the Rio Grande, Rio Gila, Rio Francisco, Rito Blanco, Rito Bonito, etc.

Hubates, Tanos comprise the region of the Placer and Zandia Mountains and a portion of the Rio Grande Valley below Albuquerque. Ruins are quite numerous in these regions, for instance those of Shi-na-na, San Lazaro, Guika, San Marcos, San José, Los Tanques, Guia, and of some buildings in the cañon of the Rio de Santa Fé near Cieneguilla.

Cicuye, Querez, Cunames seem to signify one and the same region between the Rio Jemez and Rio Grande. At present five pueblos still exist here, but ruins of extinct towns also are seen near Silla and San Felipe. Diego de Vargas also applies the name *Querez* to Acoma.

Taos and *Picuris;* these two provinces are represented by two pueblos of the present day.

Tutahaco. Castaneda mentions (1542) eight cities of this province, the position of which is southeast of Mount Taylor. At present, there still exist five pueblos, also several towns in ruins, on the Rito San José west of Laguna. The Mexican town Cebolleta was probably formerly an Indian pueblo. Mr. G. Marmon, school-teacher at Laguna, informed me that ruins of a fortified place exist on the foot-hills of Mount Taylor near the pueblo of Pojuate, or Povate. The name *Tutahaco* used by the Spaniards for this province is not known there by the Indians, nor are the names

Tiguex, Cunames, and *Cicuye*. They call themselves Tse-mo-é or Si-tsi-mé; the pueblo of Laguna, however, uses the name Kan-ay-ko to signify the inhabitants of their town, (Ko-stété,) while the pueblo of Acoma is called A-ko. I may mention here that there are two parties in this town (Laguna.) the Ka-paits, who cling to their old rites and ceremonies, and the Kayo-masho, who have progressive, liberal, Protestant ideas They are antagonistic to each other, and would once have come together in battle had not Mr. Marmon interfered at the right moment. The four other pueblos all belong to the Ka-paits.

Tiguet was a province in the valley of the Rio Puerco, northeast of the former, and was twice used by Coronado's army (1540–1542) as winter-quarters. At present, no pueblo exists in this region; ruins only—Poblazon for instance—are seen here and there. Castaneda reports twelve cities in this province, and that it was rich, and fertile, and full of fine grass. At present, the valley of the Rio Puerco looks poor and barren.

Tehua, or *Tegua*, is a province which, if the Spanish reports are correct, must have been situated in the Rio Grande Valley, about eighty miles south of the present seat of this tribe. A Tehua town, *Puara*, is often mentioned, but of which nothing is known at the present day; some old ruins near San Felipe might be related to it. There are still seven villages belonging to this tribe, six in the Rio Grande Valley and its vicinity, and one upon the Moqui mesas in Arizona. How this emigration was brought about was explained to me by Hosti, the former governador (*maire*) of Jemez. These Tehuas had inhabited San Cristobal in the vicinity of the Placer Mountains, but were driven off by Mexicans some hundred years ago, whereupon they, the Tehuas, were invited by the Moquis to live with them. Three miles above the Tehua town Tesuque is a town buried 3 feet below the present surface of the river-bank. This stream, usually but a small rill, was once, several years ago, increased to a tremendous torrent by a cloud-burst, whereby much of the former river-bank was carried off, and exposed a number of buried houses in the vertical wall of about 20 feet in height. The houses were of two stories, built of adobes, of double the thickness used nowadays. The fireplaces were easily recognized. All the wood found was charred, and it would appear as though the houses first burned before they were gradually covered with sand. It may be that a neighboring hill had fallen in and thus covered the houses. In the vicinity, about two miles northeast of there, I discovered a mass of charcoal 6 feet below the ground, in a narrow gorge.

Quivira.—This province occupies the territory adjacent to the Manzana Mountains. Here we find the ruins of Abo, Quivira, Quarro; also several Mexican towns, which, according to the Spanish writings, were probably once pueblos, (Manzana, Chichiti, Toreon.) At Quivira also are seen the ruins of the former Jesuit mission and of former habitations of Spanish miners. When Coronado visited this province, it was, as he described it, very fertile; at present it resembles a desert.

Cebola.—This province embraces the Zuñi towns, of which seven once existed; at present there are four in ruins. These ruins were visited by you in 1873.

Tusayan embraces the six Moqui towns in Eastern Arizona. No ruins of towns are seen here.

Aztlan.—This province embraces a portion of Northwestern New Mexico, the valley of the Rio San Juan and its tributaries. No pueblos exist there at the present day, but ruins of former fortified towns are quite numerous. The discoverer of the ruins in the Cañon de Chaco is Lieutenant Simpson, who made a reconnaissance in 1849, while we are indebted to Lieutenants Whipple and Rogers Birnie, both of your expedition, for the discovery of a number of interesting ruins on the Rio Mancos, Rio de las Animas, Rio San Juan, Cañon Largo, and Cañon del Governador. Some of the fortified structures had as many as five hundred rooms. Over the surrounding plain, solitary round buildings were profusely scattered. Lieutenant Whipple describes one of these ruins as being fifteen miles distant from any water; the climate, then, appears to have changed and become drier. Among the pueblos of New Mexico there exists a tradition in regard to these ruins. Hosti, a very kind, intelligent old Indian, denies that these ruins were the result of Spanish wars, remarking that, the rain falling less and less, these people emigrated to the southward long before the Spaniards arrived in the country, being led by Montezuma, a powerful man, who was born in Pecos, and had settled with the Pueblos on the Rio San Juan. Montezuma was to return and lead the rest of the Pueblos also to the south, but he failed to come back.

The Pueblos had been ordered by him to keep the eternal fire alive until his return, but generation after generation had looked for him in vain. At present, however, the fire in their *estufas* is by no means an eternal one, being kindled only at certain times. This whole tradition accords well with another held by Aztecs in Old Mexico when Cortez entered the country of Anahuac, namely, that their forefathers came (most probably at the end of the twelfth century) from the north, and their description answers very well for Northwestern New Mexico. Alexander von Humboldt, without any knowledge of the existence of ruins, supposed that the Aztecs came from the same part of North America. This explorer maintains also that some ruins on the Gila River, the so-called "Casas Grandes," (and probably also "Pueblo Viejo,") are remnants

of the Aztecs, some of whom remained on the Gila, while the majority marched on farther south. Some writers maintain that the Pueblos of New Mexico know nothing of Montezuma. In this they err; the Pueblos worship him next to the sun; at least I was so informed in Jemez. It is true that, with the Moqui Indians of Arizona, I could make out nothing on this point, a negative answer being given on my asking them whether they knew anything of Montezuma; but the pantomimes between the interrogated persons led me to suspect that in so answering they did not tell the truth. These Indians are very careful in regard to communicating their beliefs, fearing that thereby they may have inflicted upon them another Jesuit Mission, of which they have had a sufficiency: they therefore outwardly appear as Catholics, although they heartily hate this religion.

The fact that the Aztecs in Old Mexico had a monarchial government, while that of all the Pueblos of New Mexico was republican, is certainly not an argument against the theory that they came from New Mexico. Changes in form of government are more easily accomplished by some people than by others, and are especially easy when a single great man knows how to successfully lead the masses. The Aztecs might have confided their government to the family of Montezuma from feelings of gratitude or adoration. Nor does the fact that the Aztecs in Old Mexico had some customs and a style of building different from the Pueblos of New Mexico suffice as a proof against the above assertion, since the Aztecs on entering Old Mexico found tribes already there, with whom they mixed, and, as a consequence, lost some of their original features.

During your expedition of last year I had occasion to visit the ruins of Pueblo Bonito, at the head of Cañon de Chaco. The desolation of the surrounding land is in keeping with that of the habitations of the pueblo, while lizards and ants roaming amid the rubbish of the past, the crying crow nestling between the walls, and the fallen stones tell of the flight of time; but silent and mute is the ruin, no inscription telling the tale of former joys or sorrows within these crumbling walls. The ruins consist of one large building with a yard surrounded by a wall, which forms a square whose sides are nearly 200 feet long; the doors of the building open on this yard. The walls are 1½ to 2 feet thick, and are built of plates of sandstone, like those found in the immediate vicinity. The south and west sides of the square form the three-story building which descends in terraces toward the interior of the square, the second series of rooms forming two stories, the third series one story. The lowest story is 7 feet high, the middle one 9, and the uppermost 6. The most exterior row has ten rooms in the length, and therefore thirty in the three stories; these rooms measure 20 feet long by 6 feet wide. The rooms of the upper story of second (two-story) row are of the same length, but double the width of the former, while those of the first story of this row are subdivided, thus making twenty rooms, and, therefore, thirty altogether, in the second row. Into the apartments of this lower story no ray of light could enter, and they were probably larders, or rooms for provisions. The rooms of the most interior, or one-story, row were 20 feet long by 9 wide, and thus we have on one side fifty habitable rooms, or altogether one hundred, as there are two sides of the square forming the building. If we take it as probable that every room was inhabited by a family of four persons, the former population would have been 400. The rooms were all connected by openings in the walls 3 feet by 2; the window-openings were of about 2 square feet. The wood used for the construction of the doors and windows was juniper, which grows profusely on the sandy mesas, requiring but little moisture; it is in a good state of preservation. As no steps were found leading to the upper story, the ascent was probably made by ladders, as is still the custom among the Pueblos of New Mexico. In the southern corner of the yard are the walls of two cylindrical buildings, 20 and 30 feet in diameter, having six pillars on the periphery, equidistant, most likely remnants of the *estufas*, or temples, in which the sun was worshiped. The bottoms of these buildings were about 3 feet lower than the surrounding yard. Pieces of painted pottery, an article seen in exceedingly many localities in New Mexico, were found scattered about profusely; fragments of this were also found by yourself and parties even on the heights of the Sierra Blanca in Arizona, on the Mogollon mesa in the San Francisco Mountains, on Mount Taylor in the Cañon de Chellé, and, in short, everywhere, in deserts as well as on the forest-covered peaks.

I searched the surrounding ground for the former burying-place, but in vain. The discovery of a few skulls would have been interesting for examination. No trace of former irrigating-ditches can be found in the neighboring valley of the Chaco, but there are traces of a former road to Abiquiu, sixty miles off, where ruins have also been found, two in the immediate vicinity and three between Abiquiu and El Rito. Dr. Yarrow (in charge of division No. 6) made excavations in these ruins, and in the old burying-ground about four miles below Abiquiu, on the Chama.

The province of Jemez.—One of the most interesting pueblos is Jemez, on the river of that name, sixty miles southwest of Santa Fé. This town has a language of its own, and one which is unintelligible to any other tribe. About forty years ago the then existing pueblo of Pecos, on the Rio Pecos, used the same dialect, but the inhabitants, becoming reduced in number, joined the pueblo of Jemez, which is one of the

most prosperous in New Mexico, having fine fields, large irrigating-ditches, and extensive flocks of sheep. "If you wish to see," said the kind old Hosti, ex-governador of the town, "what a great people we once were, (*que gran pueblo los Jemez eran,*) you must go upon the mesas and into the cañons of the vicinity, where ruins of our forefathers are numerous. Our people were a warlike race, and had many fights not only with the Spaniards but also with other Indian tribes, the Navajos and Taos for instance, and were thus reduced to this pueblo of Jemez, which now forms the last remnant." Hosti's son led me to some ruins in the vicinity. A ride of six miles up the river brought us to the junction of the two great cañons, Guadaloupe and San Diego. Where the mesa between these cañons narrows itself to a point are the ruins of two pueblos, one upon the lower prominence of the mesa, named Batokvá, the other upon the mesa proper, called Ateyala-Keokvá, and only approachable by two narrow, steep trails, the mesa everywhere else being nearly perpendicular and 750 feet high. The view from the mesa is picturesque and imposing in the extreme; far beneath, to the right and left, a stream makes its way between the colossal walls of sandstone, which are penetrated by trachytic dikes; upon the narrow width of the mesa, near frightful precipices, are the ruins of a town of eighty houses, partly in parallel rows, partly in squares, and partly perched between the overhanging rocks, the rim and surfaces of which formed, at the same time, the walls of rooms, gaps, and interstices being filled in artificially. Nearly every house had one story and two rooms; the building material was trachytic rock, as found upon the mesa. Broken pottery, charred corn, and millstones for grinding corn, were found in some of the rooms. The roofs had all fallen in, and so also had many of the sidewalls, in the construction of which wood was but little used. Piñon-trees have taken root within many of the former rooms. Upon asking my Indian guide whether the former inhabitants of this town were obliged to descend the steep and dangerous pathway every day to the creek to procure water, he replied that there were cisterns on the mesa, in which rain, formerly plentiful, was caught. He then called my attention to some conical heaps of stone along the rim of the precipice, which was the material for defense. Although the position upon this mesa appears impregnable, the Spaniards succeeded in taking it, probably forcing the inhabitants to surrender by cutting off water and provisions. "When the Spaniards came up," said this Indian, "the despair of the people was great; many threw themselves headlong into the frightful depths below, preferring suicide to humiliating death at the hands of their conquerors. Suddenly the Spirit Guadalupe, who is the custodian of the cañon, made his appearance, and from this moment the people could jump down without any danger, and since this remarkable episode the image of Guadalupe has been upon the rocks." On descending, I viewed this image, which is a white figure, about ten feet in length, painted high up on the vertical bluffs, apparently a difficult task for the unknown artist. The only place from which the spot could be reached is a narrow prominence 30 to 40 feet below the picture. As there is a sort of halo around the head, such as we are accustomed to see in pictures of saints, I believe this image to be the work of a Spanish priest who desired to impose upon the people, for which purpose he might have secretly made this picture, which to them is a miracle. Again, in the valley, the Indian called my attention to a number of peach-trees along the river-margin, which he said were planted by the former inhabitants of Ateyala-Keokvá, and, from the fact that these trees still blossom and bear fruit, it would seem that the impositions on the credulity of these people by the Spanish priests are not of a very remote period.

The reports of the Spaniards frequently mention Jemez. Castañade, who accompanied Coronado on his marches through New Mexico, as early as 1541–'43, speaks of two great provinces in that vicinity, Jemez, and north of it Juke-Yunke. He also speaks of strongly-fortified places difficult of access, and of a town, *Braba*, that was called by the Spaniards *Valladolid* on account of the resemblance of its situation with that of this Spanish town. I think that from this word is derived the name *Vallatoa*, used at the present day by the inhabitants of Jemez to signify their town. In the years 1692 and 1693 two war expeditions took place, under General Diegode Vargas, against the Jemez, who had destroyed the churches, murdered the priests, and declared themselves free from the Spanish yoke. In the Spanish account of these occurrences, it is mentioned that the Indians fled to a high mesa and there bombarded the Spaniards with a shower of stones. Trustworthy Mexicans told me that there are ruins of twenty-five or thirty towns upon the neighboring mesas and in the cañons, and those of five large churches. In the vicinity of the Hot Springs, (Ojos Calientes,) twelve miles above Jemez, in the Cañon de San Diego, are the ruins of one of them. The walls are fully 7 feet thick, and the interior space 100 feet long by 35 feet wide, with a tower attached on the north side. The destruction of this church building probably took place in 1680, at the time of the great Pueblo revolution against the Spanish priests and soldiers.

It may be added, with regard to the Pueblos of the present day, who hardly number more than 8,000 souls, that, taking difference of language * as a base, there are eight tribes, which occupy the following towns:

* Vocabularies of all the Pueblo languages, except the Zuñi, were collected by the members of the expedition, each vocabulary embracing about two hundred words.

Zuñis.—Zuñi, Natrias, Ojo de Pescado.
Moquis.—Huatl-vi, Tsi-tsume-vi, Mushangene-vi, Shongoba-vi, She-baulavi, Oray-vi.
Tanos.—Isleta, below Albuquerque; Isleta, below El Paso; Zandia.
Taos.—Taos, (Indian name, Takhe,) Picoris.
Querez.—Santa Ana, (Indian name, To-Mia,) San Felipe, San Domingo, Silla, (Indian name, Tsi-a,) Cochiti.
Kan-ayko or *Si-stsi-mé.*—Acoma, (Indian name, A-Ko,) Laguna, (Indian name, Kan-Ayko,) Povate, (Indian name, Kvi-shti,) Moguino, Hasatch.
Tehuas.—Nambé, Tesuque, Ildefonso, Pajoaque, San Juan, Santa Clara, Tehua, (with the Moqui-Pueblo in Arizona.)
Jemez.—Jemos, (Pecos extinct.)

The language of the Kan-Ayko tribe resembles closely that of the Querez tribe; and, on the other hand, the languages of the Tanos and Taos tribes are closely allied to each other. With these two exceptions the languages of these tribes differ so much that, in order to understand each other, those speaking them have to take recourse to the Spanish language. Buschmann, who made a specialty of the study of Indian languages, denies the existence of any relation between the different Pueblo languages, and also any relation between these and the Aztec language; but he evidently had only the scanty material then known of these languages—vocabularies not containing over forty words, (Zuñi excepted, of which in 1856 Lieutenant Whipple collected a long list)—from which to form his conclusions. In order to show that there are really relations, although limited, between not only the Pueblo languages, but also with the Aztec idiom, I take the word for "hand" as an example:

Querez and Kanayko.	Tehua.	Moquis.	Taos.	Tanos.	Jemez.
Shka-mástsi	Mâ	Ma-khde	Mane-na	Man	Mâ-tash.

In Aztec *ma-itl* means hand; in Yuta, *mû.* No one would assert that the repetition of the syllable *ma* is a mere accident. No doubt these Pueblo languages were derived from a common origin, like the widely-differing European languages from the Sanskrit; but time, measured by centuries and not by single years, has gradually effected changes, and to such a degree that to one who does not examine these languages very minutely, they appear devoid of any relation to each other.

Respectfully submitted.

O. LOEW.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

J 3.

REPORT ON CERTAIN RUINS VISITED IN NEW MEXICO BY LIEUTENANT ROGERS BIRNIE, JR., THIRTEENTH UNITED STATES INFANTRY.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL EXPLORATIONS AND SURVEYS
WEST OF THE ONE HUNDREDTH MERIDIAN,
Washington, D. C., April 30, 1875.

The evidences that there were former inhabitants in localities now entirely depopulated were numerous, being observed along the Cañon Cerresal, Cañon Largo, Cañon de Chaco, and the San Juan and Las Animas Rivers. Traveling through the Cañon Cerresal, they were first observed as rude walls built upon the rocks, at the top of the walls of the cañon, where these latter were from 150 to 200 feet in height.

On September 16, 1874, I visited, with Mr. Rowe, a topographical station at the head of one of the branches of the Cañon Cerresal, where we found some very perfect specimens of old pottery, though no signs of any habitation. It is one of the highest points in quite a large area, a small-topped sandstone mesa about 100 by 40 feet, the upper terrace as it were of a series, and well-nigh inaccessible. It is difficult to conceive for what purpose this place could have been frequented, in the present aspect of the country, situated as it is probably twenty miles from any permanent source of water, unless, with the positions of the dwellings, it may tend to corroborate the idea that these people were driven out of the country by roving tribes of Indians, and sought refuge in these naturally-fortified places.

Returning to the party from this station, we visited one of the stone houses built

PLATE IX.

T. Sinclair & Son, lith. Phila.

RUIN IN THE PUEBLO SAN JUAN, SHOWING WALLS OF ROOM IN THIRD STORY

upon the rocks above the side of the cañon. The ascent to the rock upon which it is built was by two pieces of wood about 10 feet long, with notches cut for steps and forming a rude ladder. There were six rooms, some nearly perfect, the walls of rough stone and roof made of pieces of cedar stretched horizontally and covered with earth; patches of plaster remained upon the walls, but much of the roof had fallen in; the ceilings low, not more than 7 feet above the ground; doors very small; broken pieces of crockery seen scattered about.

On the next day (September 17) I visited another of these ruins, making the ascent of the rocks with considerable difficulty. Several small dwellings were found, nearly covering the space upon the rock, which descended very abruptly on every side. In one of these houses, just above a fire-place, and upon sticks stretching across the room, supported by being embedded in the wall on either side, I found the leg-bones of a man's skeleton; the remainder must have been carried away, as I could not find any of the other parts. Near the dwellings were several cavities in the rocks suitable for holding supplies of water, although they seemed to be natural formations. The rubbish on the floor was an inch or two thick.

In the Cañon Largo, a few miles from its junction with the San Juan River, we found a curious mound in the valley, that had every appearance of having been constructed by man, from the heterogeneous substance that composed it as well as its shape, roof-like, with sloping ends, being about 100 feet long by 50 feet wide at the base, and 25 feet high. At either end were little circles of stones, and digging down through the sod, a quantity of black earth was found as though the place had been frequently used for fires.

The most extensive ruins met with were on the right bank of the Las Animas River, about twelve miles above its junction with the San Juan. I had been previously informed of this, my informant stating that he had counted 517 rooms in one pueblo. On visiting the ruins we found what had once been, apparently, quite a town, with two main buildings and numerous small ones about them. One of the main buildings, situated nearest the river, extended to and was built into a bluff separated a few hundred yards from the river by a flat. The plan was rectangular with a small court on the south side, the court flanked on either side by two circular rooms or towers at the corners of the building; two more of these rooms at the other corners, and three through the center and parallel to the longer side of the building; the walls supporting the towers on either side of the court were square-cornered, but had re-entrant angles. The remainder of the building was divided into rectangular compartments apparently of three stories, the two upper ones nearly in ruins, on two sides of the building, which was about 150 by 100 feet; the wall was quite perfect and in places 25 feet in height still standing. (See Plate IX.) Entering a room nearly altogether in ruins, it was found connected with an interior one by a door-way 4 feet 4 inches and 2 feet 4 inches, cased with nicely-dressed soft sandstone about the size of an ordinary brick; the walls were 2 feet 4 inches thick, many of the stones being marked with crosses, (+) &c., and some with inscriptions, though these latter were nearly obliterated. The interior room was 14 feet 4 inches by 6 feet 4 inches, and the roof fallen in. An entrance was found to a lower room, apparently one of the lower story, through a door of about the same dimensions as the other mentioned; the lintel was composed of small round pieces of wood well cleaned, fitted, and bound together with withes; the dimensions of the room 14 feet 4 inches by 6 feet, and 7 feet high; the walls had been well plastered, and remained nearly intact, though covered on all sides with curious figures and signs scratched upon them. The floor must have been of earth; the ceiling was supported primarily by clean pine or spruce beams about 6 inches in diameter, and 30 inches apart; these were crossed by smaller ones of the same kind, and across these latter were split pieces, small and half-round, and fitting closely together, supporting the earth above. The room was in good condition, though sand had washed in and partly covered the floor. No entrance could be found to the numerous other rooms constituting this floor, except in one case where an interior wall was found broken through. This room was like the other, but higher and without plaster, the floor covered with *débris* fallen from above. Near the center of the building was a rectangular shaft about 8 feet by 6 feet. Through a hole already broken in the roof and by means of a rope I descended this about 12 feet to a flooring, the beams supporting which had given way and only part remained; a little below loose earth filled the shaft, but whether resting on another floor, or the ground, I could not tell. No connection was found between this and any of the rooms. I regretted that I could not reach the bottom, as I had here hoped to find entrances to those rooms which appeared to have none from the outside. Holes, as if for ventilation, but not large enough to admit a man, and now filled with dirt, seemed to extend through the exterior walls of the building in places.

The other main building, which is the larger of the two, is about 200 yards to the west of this, and quite remarkable in plan. What was probably the principal part is on the north side, the roof fallen in and much *débris* about the exterior. We found a number of much larger rooms than in the other building, and interior walls at least

30 feet high. This portion of the building is about 200 feet long and regularly supported on the exterior by buttresses; from either end two wings connect and run out, making the interior angles about 100°; these wings extend about 150 feet, then their extremities seem to have been connected by a circular wall, now entirely in ruins but showing the remains of a gate-way. Above the buttresses on the exterior wall of the main portion the wall is quite perfect, and shows some very pretty architectural design. The masonry is not only built with courses of different thicknesses of stone, but, also, of different colors. There is seen a projecting cornice, plain, composed of three or four courses of very thin reddish sandstones, and again a course of nearly white stone, perhaps a foot thick, both very even, and then other courses of different shades and thicknesses alternate. In this building there are remains of three circular rooms, one at each of the angles above referred to, and one in the center of the court. A great deal of broken crockery was about, but confined to certain portions of the building, principally the extremities of the wings. Want of time prevented me from making measurements and obtaining much accurate data that I desired.

Many years must have elapsed since these buildings were in ruins, but some of the walls, where supported, are well preserved. Very heavy sage-brush was growing in many places upon the mounds of the ruins. The remains of a circular building were found midway between the two main buildings, and it has been supposed that these circular rooms were places of worship. But little analogy could be observed between these and the Indian pueblo at Taos that I afterward visited; but stone ruins seen at Nacimiento and near other (now occupied) Mexican towns were very similar, except as to plan, to those described, the ruins about the towns being entirely different from any of the present habitations.

In many places along the San Juan River, pieces of old crockery were observed and remains of several small stone houses. In one of these I found a very fine specimen of a stone hammer, oval and of natural shape, with the ordinary groove cut about it for attaching the handle. A number of important ruins were also observed along the Cañon de Chaco. None of those so minutely described by Lieut. Simpson in 1849 were visited by us, as we did follow his route only perhaps a very short distance. The Navajo Indians ascribed some of the figures and signs seen in the lower room of the ruins to Apaches and Comanches; but their explanations were very vague, principally from the difficulty of understanding them.

Respectfully submitted.

ROGERS BIRNIE, JR.,
First Lieutenant Thirteenth Infantry.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

J 4.

REPORT ON THE PUEBLO LANGUAGES OF NEW MEXICO, AND OF THE MOQUIS IN ARIZONA; THEIR AFFINITY TO EACH OTHER AND TO THE LANGUAGES OF THE OTHER INDIAN TRIBES: BY ALB. S. GATSCHET, PHILOLOGIST.

NEW YORK CITY, *April* 24, 1875.

Although the vocabularies of the Pueblo languages collected by Lieutenant Wheeler's parties are more complete, and contain more material than any others so far submitted for investigation, still the data obtained are not such as to admit of a complete report upon the grammatical structure of these interesting idioms; they are, however, at least copious enough to give us an idea of their utterance, phonetic character, and a glimpse at their affinities. But, being as yet debarred from sufficient materials to derive grammatical rules and paradigms, we cannot be too careful in drawing conclusions on the pedigree of the half-civilized tribes who use these dialects as their means of intercommunication.

The most decisive criterion for the affinity of one language to another is the similarity of their inflectional terminations and the equality of their terms for degrees of consanguinity, as father, mother, son, sister, &c.; for numerals and personal pronouns; for denominations of the diverse parts of the human frame; the most common animals and plants; the colors; a man; woman; sun; moon; star; fire; water; and the seasons. When a majority of these terms agree, there is a strong probability that both languages compared are but dialectic variations of the same stem, and that in former times a mother-language has existed for both. A close comparison of the above terms in all the Pueblo idioms spoken in New Mexico and Arizona has prompted me to classify them in four distinct families, as follows:

First family, with four subdialects: Isleta, (with Zandia in New Mexico and Isleta in Texas near El Paso;) Jemez, (with Pecos;) Taos, (with Picuris;) Tehua, spoken in San Juan, Santa Clara, Pojoaque, Nambé, Tesuque, San Ildefonso, and on one of the Moqui mesas.

Second, or Quéres family: Spoken in San Felipe, Santo Domingo, Cochiti, Santa Aña, Cia, Acoma, Laguna, Povato, Hásatch, and Mogino, with some dialectic variations.

Third, or Zuñi language: Spoken in Zuñi, Ojo de Pescado, and Las Nutritas.

Fourth, or Moqui language: Spoken in six villages situated on four high bluffs north of the Colorado Chiquito, Arizona.

The vocabularies collected by Dr. Oscar Loew (the Taos was collected by Dr. Yarrow) exhibit an almost equal number of vowels and consonants, and a predominance of vocalic sonorous terminations of syllables and words. Their utterance thereby becomes harmonious and pleasant to the ear. In this they differ largely from their neighbors, the nomadic and hunting tribes of the Apaches, Comanches, Kiowas, and Utes. All Pueblo idioms, perhaps excepting the Zuñi, seem to have a monosyllabic basis, and words having more than two syllables are probably compounds. Hiatus of vowels often occur, as in ki-é, bear, (Tehua;) tsa-an, pine tree, (Taos;) ho-ana-an, eye, (Quéres.) Nasalized vowels are scarce in the Quéres dialects and in Taos, but are abundant in Moqui and Tehua, (ŭlŭhŭŭ, hot, Moq.,*) and often occur in Jemez and Isleta, (hŭla, goose, Jem.; tē, belly, Isl.) We often find words interrupted in their midst by an abrupt coughing effort of the mouth, as in p'-ē, sun, Jem.; gā'-ē, Indian corn, Moq.; p' ay ade, dead, Isl.

Pueblo words often undergo similar changes and substitutions as we observe in the Aryan languages when they make their re-appearance in cognate dialects. The transition observed between Latin and Greek *pater* and the English *father* is recalled spontaneously to our mind when we behold the following consonantic substitutions:

Tehua: po-oyo, fly; Jemez: fu ya.
Teh: p'-ho; Isleta: p'*a*, hair; Jem: fola.
Isl: puñai, nose; Jem: fóse
Isl: adpa, beard; Jem: tūfū.

Transitions of the tenuis into the corresponding media occur quite as often:

Teh: pó, squash; Taos: ba-a.
Jem: pe-el, heart; Isl: béa.
Teh: po-oye, three; Taos: bíhi.
Teh: henti, black; Taos: funte; perfectly coincides with the transition from ἐσθής to Latin *vestis*, garment, and similar consonantic changes may be observed in—
Taos: puíyu, friend; Zuñi: Kúayi, (like κοῖος and ποιος)
Teh: húa, egg; Moq: ne-hŭ; Isl: ba-gué.
Teh: ko-oa, leaf; Jem: hā-ā.
Acoma: hótsen, chief; Quéres: hótchen.
Ac: í-atch, boy; Qu: í-uas.
Ac: tchoshk, coyote wolf; Qu: shotsoná.
Isl: gaindá, horse; Teh: shaniya.
Taos: bihio, three; Isl: batchoa.
Teh: tchi-e, bird; Moq: tsi-i; Jem: seye; Isl: shira.

Consonantic mutations, unusual or unheard of in Indo-Germanic languages, are the following:

Ac: taña-e, good; Qu: rauátsa, raña.
Ac: and Qu: kagan, wolf; Taos: kalen.
Isl: tlo-a, arrow; Jem: sh-tiā.
Isl: tle-e, tobacco; Jem: tio ye.
Isl: tlórida, rain; Jem: tokā.
(Span: burro, mule; Teh: bunto.)

Up to this time we have quoted only instances of consonantic mutations. Considerng at the same time the vocalism and the consonantism of these idioms, and supposing that the words compared formed parts of one and the same language, we observe alterations which might be called as follows:

Prothesis or *Aphæresis:*

Teh: gasūa, to drink; Isl: āsui.
Isl: ahoi, to kill; Taos: hoyar.
Jem: to-u-a, wind; Isl: na (=idŭ).
Teh. II: nakie, strong; Teh. I:† akiele.
Jem: hŭ, bone; Isl: ŭ.

Epenthesis, Ekthlipsis, or *Syncope:*

Teh. I: epile; Teh. II: epíe.
Isl: kiye, feathers; Jem: kea (-ta).

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* ŭ=a nasal sound between *u* and *o*. ē=a nasal *e*.

† I call Tehua I the subdialect spoken in San Ildefonso and on one of the Moqui Mesas; Tehua II the dialect in use in the other Tehua settlements.

Acoma: í-atch, boy; Qu: i-u-as.
Ac: háni, pine tree; Qu: ha-aní.
Ac: mátse, blood; Qu: má-atse.
Isl: tloa, arrow; Jem: (sh-) tiă.
Teh: ko-oa, leaf; Jem: hā-ā.
Isl: panto, five; Teh: pano.

Epithesis or *Apocope:*

Teh: hua, egg; Moq: (ne =) hũ.
Jem: pe-el, heart; Isl: béa.
Jem: nono, here; Isl: nuu.

Nasalizing:
Tsuque: au', foot; Teh. I: ũng; Teh. II: ã; Isl: en.
Isl: opeõ, girl; Jem: umpe (—kule).
Teh. II: gasuã, to drink; Isl: ãsui.

Most Pueblo languages are deficient in some of the sounds occurring in Aryan and Semitic tongues; *gs*, *ks* (*x*), and *ds*, *ts* (*z*), seldom occur, the latter being generally replaced by tch. In Quéres, *tch* replaces *s* and *ts*; *sh* and *k* are very often met with; *tl*, so frequent in Aztec, we find only in Isleta and Taos.

Though the Pueblo languages exhibit many mutual affinities in etymology, they are nevertheless totally differing among themselves, and on examination not one of the decisive terms mentioned above will be found to agree in all. The numeral *three* disagrees only in Quéres, *four* in Moqui. Names of colors all terminate in -*i* in Isleta, (as do many adjectives,) most of them in Tehua, and in -*ri* in Moqui. Words that agree in the majority of the Pueblo dialects are: the pronouns *I* and *mine;* the numerals *two, three, four; water, bird, stone, leaf; sun, head, squash.* It is very probable that *sun* and *squash* were compared to a head on account of their circular shape, and were called by the same word.

All Pueblo languages are in possession of a large stock of words entirely of their own, which do not allow of any comparison with terms of equal or similar meaning in other Pueblo idioms, or in Yuma, Pima, Ute, Apache, Shoshone, or any other neighboring idiom. But the number of words in which an affinity is traceable is perhaps as large; and if we had sufficient material from which to construct grammars, we should probably find many close and striking affinities. We subjoin a number of lexicographic correspondences between aboriginal and Pueblo languages and their respective headings.

The Pueblos have borrowed very few terms from the Spaniards, French, and other European settlers, and even objects, as *horse, rifle, gun, gunpowder, money, coffee, soap, bread, sugar*, are in many instances rendered by Indian and not by imported terms. In this respect the vocabulary of the Comanches published by Buschmann (*Völker und Sprachen, Neu Mexicos*) is of great interest, for notwithstanding their continual intercourse with Mexicans, they have adopted almost no words from them, (ex.: *casa*, buffalo lodge.) The cause of this is probably the intense hatred of all the southwestern tribes for the Mexican people. The Pueblos adopted from them *kavayo*, horse; *lengi*, tongue, (Moq;) *binto*, wine; *bunto*, mule; *palomo*, pigeon, (Tehua;) and some others.

ISLETA.

The dialect of this Pueblo is most closely related with that of Jemez, somewhat less with that of Taos, and still less with that of Tehua. In some instances, Isleta exhibits more complete and probably older forms than Jemez; agrees with it in most terms for parts of the human body and for degrees of consanguinity, in a few names of plants and in most minerals, but differs in names of animals and in colors. With Tehua it coincides in five numerals, in most colors, and terms for limbs of the human body. With Taos, the coincidence in the numerals is more striking than in the terms for parts of the body, but both dialects exhibit for the latter, and for the degrees of consanguinity, an ending which seems to be of a common origin, (-idắ,-odẵ, in Isl.; -ẽ́, -ẵ, in Taos,) and certainly has an emphatic and demonstrative signification. A similar ending is found among the Dakotas and other northern tribes. Isleta has very few words in common with Apache, Yuma, and Quéres dialects, apparently none with Moqui, but some with Zuñi, and many important ones with Kiowa. It abounds with the sounds *sh*, *tch*, *tl*, and with nasal vowels; *f* occurs less often than *l*, and *r* is rarely met with.

Zuñi words cognate to Isleta:
tlatē, canoe; Z: thléloni.
panidẵ, snow; Z: upinaive.
ka-āv, moccasins; Z: mókuovi.
to-uinidẵ, winter; Z: to'anaye, autumn.
Kiowa words related to Isleta:
natũai, town; K: tuôi.

pa-a-idá, fire; K: pía.
k'-auva, neck; K: k'-aul; Shosh: kvió.
c'-atui, white; K: -'tai.
p'-aiade, dead; K: peto.
tchori-i, yellow; K: córta.
The numeral *one, uima,* agrees with Pima yumako.

JEMEZ

Has a dialect closely allied to that of the Isletas, (see Isl.) The vowels in words which are common to both often appear protracted or lengthened in Jemez, (and in Tehua;) for instance:

Isl: hi-au, rock, stone; Jem: kea-ā.
Isl: kai, leaf; Jem: hā ā; Teh: ko-o-a, ko-ā; Tes Kūko-ua.

Jemez is replete with nasal vowels, especially ũ, but lacks the coarser gutturals and *r*, which is replaced by *l*. (*r* occurs in foreign words.) For its relations to Taos and Tehua, see Isleta. There are only a few, but striking, similarities between Jemes and Dakota:

tota, neck; D: dote, tahu.
kiune, flesh, mea: D: konika.
hũ, bone; D: hu, huhu.
valo, bear; D: varark = sika.

Some others, equally important, are found between Jemez and some languages of Southern California belonging to the Shoshone family:

caboye, elder brother; Kechi: popêt.
p'-a, water; Kizh: bar; Netela: pal; (ath apask-pa.)
pa=kva, river; Kizh: p=khait.
no-osh, cold; Kizh: otchō, otsō.
pũ, one, (num.;) Kizh. and Netela: pukū.

With the Comanche there exists a remarkable coincidence in the pronouns *I, thou, he:* ne, nugva, na-ā; Com: nu, nnoso—eunes, and in a few other words; but with Yuma no affinity seems to exist. In Zuñi the following terms should be compared:

hē-ī, people; Z: ho′-ite.
hā-ā, leaf; Zuni: ha′ve.
yakvā, fire; Z: máki.
hōshulo, red; Z: shìlova.
kea-ā, rock; Z: áve.
keapa, dead; Z: háppa.

Kiowa shows affinity to Jemez where Isleta mostly disagrees in the words:

mā-tash, hand; K: mórta.
p'-e, sun; K: pai.
p'-a, moon; K: pa.
tā-h-l, winter; K: tuh.
pũ, one, (num.;) K: páhco.
pento, five; K: onto.
kuine, meat; K: ti.
(p'-a—) shtyo, sea; K: sé-itzo.
doyo, house; K: tu.
petā, valley; K: pi′-sti.
mieshtyo, six; K: mósso.
For affinities with Moqui, see Moqui.

TEHUA.

The three dialects of Tehua of which we possess vocabularies do not show any marked differences, and even many of these might be accounted for by the individualities of their transcribers and their dissenting graphic systems. Tesuque seems to hold a middle position between San Ildefonso (Tehua I) and San Juan, (Tehua II;) and all three do not differ as much as Scotch does from English. Their differences and similarities appear from the following table:

Tehua I.	*Tehua II.*	*Tesuque.*
ia (=kom), blood	ũ	ũ'-
toyā, chief	tuyó	to-uyā
shu'-, arrow	su	tsu
shá, tobacco	sa	sāh
b'-ō, moon	p'-o	p'-ho
tavente, spring	ta-andé	to'-ondih
vā, wind	nā	mua-o
kueko, iron	goáko	kuanku

To derive any phonetic laws from these and other words for the three dialects would be premature as yet. The vocabulary of the Tesuque Indians, collected by David V. Whiting, will be found in *Schoolcraft's Indian Tribes*, vol. iii, p. 446.

From a few sentences transmitted by Dr. Loew, we can safely deduce the following grammatical rules for the Tehua idiom:

The verb is not inflected. The particle indicating the past tense is –n–; the future tense, ka . . . ta' k'– . . . ta. The personal pronoun is generally placed after the verb; *I hear*, is not *na oto*, but *oto na*—"*hear I.*" The negative particle used in sentences is *ve . . . be, v' . . . . be.* A personal pronoun can be substituted for the substantive verb *to be*, or else the position of the words can supply it. Adjectives, even when used as predicates, and numerals, generally precede their substantives. There is one set of demonstrative pronouns for animals and another for inanimate objects; but the existence of distinct cases and numbers is doubtful. Every Tehua dialect has words of its own; but in numerals and personal pronouns all of them agree pretty well.

A distant relationship with the Wichita can be observed in five words: with Central America in *tata*, father, (tat in Guiché; táta in Palin;) with Quéres in *woman*, *bird*, and *bear*. But there are many important affinities with Zuñi, Moqui, Kiowa, and the languages spoken in the southern part of California. Tehua agrees with Apache and its kindred idiom, the Návajo, in many important terms, as *fire*, *water*, *bow*, *bird*, *wing*, *sált*, *nose*, but disagrees entirely in the personal pronouns and numerals. Of all these relationships, the one with Kiowa is the most conclusive, and we are forced to admit that at one time both nations must have lived in close contiguity and prolonged intercourse. The name "Kiowa" seems to be derived from the Tehua kā-i, far distant, (khu-au-ay in Isleta,) thus designating their roving bands as coming from afar; the name of the Tehuas (or Teguas) from a word of their own language, (téhua, house; tu in Kiowa.)

TAOS.

Attentive readers of the Taos vocabulary will perceive at the first glance its numerous affinities with Tehua, Jemez, and especially with Isleta, and the many important words in which it differs from them may, nevertheless, belong to a common stock of Pueblo roots, of which our knowledge is yet so restricted. The Picuris are said to differ somewhat in their dialect from Taos, and to have adopted many expressions from their neighbors, the Jicarilla Apaches.

In Taos, *r* and *kh* are scarce; *tch* and *ts* numerous; *f* often occurs, and alternates with *p* and *h* in Tehua words. Verbs often terminate in –a, which is probably a suffixed personal pronoun. Most terms for animals and plants, also water, ice, (and salt, *enye*,) terminate in the accentless endings –an, *–ane*, *ana*, –nen. For the ending –ă see Isleta.

With the Acoma dialect of Qúeres and Taos there is more affinity than between Acoma and the much nearer Isleta. With the Apache dialects and that of the Tonto Apaches, who call themselves Gohuns, and belong to the Yuma stock, I found the following terms resembling each other:

tchum (–o-vayé), heart; Ap: itchi. (Whipple: tchu-li.)
kana, moon; Ap: Kli-una-ai; Gohun: k'-lá.
tsuden, dog: Ap: (li–) tchane; Gohun: ts–ta; Aztec: tchitchi.
tchuli, yellow; Ap: tlitsu; Náv: sitsu.

With the Caddo, (Texas,) I find a fortuitous coincidence in the word yuyeyá, to march; C: yoyá; and the three affinities occurring in Otomi (Central Mexico) are perhaps just rtuitous:

kana, moen; Ot: tsānā.
(ba-) tchista, star; Ot: tstse.
kiahea, leg; Ot: Khiuté.
Taos approaches to Zuñi in the following terms:
Sapana, beard; Z: siponive; Kiowa: sénpō.
puiyu, friend; Z: Kúayi.
tuvan, evening; Z: tévani.
ilap, feathers; Z: láve, feather.
ho-ená, no; Z: holó; Kiowa, hoani.

With Kiowa many more affinities are traceable, but they are not of so important a character as those observed in Tehua. A few of them are:

papaná, elder brother; K: papīe.
bihio, three; K: páo, (Moqui páhio; Kizh and Netela: pahó, pai.)
etuha, to speak; K: emtúmki.

QUÉRES.

There is so little variation between the dialects of this Pueblo language that they can fairly be considered as one and the same tongue. It stands for itself, and shows very few and no conclusive affinities with other families. Even in their tall stature, the Quéres differ conspicuously from their smaller neighbors.

Quéres abounds in sibilants, gutturals, and spirants (*h*), but lacks *b*, *d*, *f*, and *l*. *r* is

almost entirely wanting, and is not replaced as elsewhere by *l*; it occurs in *ranátsa, raná*, good, where Acoma has tanáe, Kiowa tú (-senau), and in the name of the people itself, (Quéres, Kéres,) which has probably been bestowed on it by other tribes. The terminations of words and syllables are not so vocalic as in Moqui and Isleta, and we often find them ending in -m, -n, -tch, -t.

Mine is rendered by the prefixed s–, sa–, sh=; *va* seems to be the negative particle. No distinct sign of a plural can be discovered. For phonetic differences between Quéres and Acoma see our table, p. 6, (Epenthesis, &c.)

There are many terms in Quéres congruing with equivalent Zuñi words, viz:

hatchtche, man; Z: ótsi, quiché, atchi.
kue, woman; Z: ókia, ókare; Teh: kui, kvi.
hópin, forehead; Z: háquin.
stsiumi, arm; Z: tchútiove.
sh=tsau-itch, mails; Z: shaúntchiove.
ishiane'-e, flesh, meat; Z: shile.
yomatse, cold; Z: tetse.
tsina, turkey; Z: tóna.

With the Apache dialects we find affinity in the terms for nose and hot, (ka-atche, hot; Nav: khotsto,) with Moqui in Ac: (mé-)tsia, small, little; Moq: tchai-o.

Qu: (shka=) matchatchi, fingers; Moq: malatchi.
Ac: shui; Qu: shu-ui, snake; Moq: tchu-ash.

The idiom of the nomadic Kiowas furnishes the greatest number of correspondencies also with this Pueblo family:

ko, kue, woman; K: kiúng, woman; kó, mother.
sh-kaúi, neck; K: k' oul; Utah: koloh, kuravh; Teh: k' -ó.
hóaka, sky; K: ki áko.
uáka, bark; K: touko-i.
shu-ui, snake; K: saoni.
k ayátauish, Ac: bird; K: kúatch.
ko-otchini, yellow; K: kórta.

ZUÑI.

The Zuñis, who call themselves Shi-ou'-i, possess a language built up mostly of polysyllabic stems, and entirely peculiar, though showing many words held in common by the Pueblo and other Indian languages of the southwest. Eaton's vocabulary will be found in Schoolcraft, vol. iv, p. 416–431; Lieutenant Whipple's in Senate Doc. No. 78, Survey Pacific R. R., vol. iii, p. 91.

The accent generally rests on the first syllable, which leads to the supposition that many of the appended endings are pronominal or other suffixes. In numerals, the quinary counting method obtains, and the numbers from 6 to 9 are formed out of 1 to 5 by adding *likiā*, "the other," meaning evidently the fingers of the other hand. No other Pueblo follows this counting method, but we observe it also in Yuma, Gohun, and in Tonkawa, (Texas.) All words and most syllables end in vowels; the parts of the human body generally terminate in -im, -tin, -quin; the degrees of consanguinity in -i, (-li, -shi;) the terms for implements in -li, -di; *i* being probably the pron. poss. *mine*. Adjectives, especially when designating colors, end in -ni, -na. Observe the following significant groupings of words with similar endings:

Plants: grass, (and valley,) péve; leaf, háve; tree, taneaive; Indian corn, mive; (feather, láve.)

Inorganic objects: rock, stone, áve; water, kíave; land, sóvi; salt, máve.

For corresponding terms in the Pueblo, Kiowa, and other languages, see *supra*.

MOQUI.

In spite of the isolated geographical location of the four inhabited Moqui mesas in the midst of an ocean of sand, rock, and *débris*, and of the antiquity of these Moqui settlements, we can discover many points of resemblance between their idiom and those of the neighboring Indians, which prove an ancient intercommunication. Nasals are of frequent, *d* and *l* of scarce occurrence; *f* is wanting. Sentences are negatived by means of the particle *ka;* the particle for the preterit is *na*. Personal pronouns precede the verb, which is not inflected, and the negative *ka* is inserted between the pronoun and the verb. Most words for colors, numerals, and consanguinity are peculiar to the Moqui. The terms of animals and of some plants terminate in -ē. The terms for parts of the human frame are not connected with the pronoun *mine*, as they are in the other Pueblo idioms; and in this Moqui agrees not with Comanche, but with the eastern Shoshone languages.

Buschmann, who knew only the thirty words of Marcy's vocabulary, pointed out of their number five terms cognate with Sonora words, and five others occurring in Aztec, and directed attention to the termination -pe, -pi, in *quape, kvapi*, (neck,) which, in Aztec,

forms substantives, and occurs also in the Comanche word *mash-pa*, hand. Congruencies with Comanche, which is related to some Sonora languages, are very numerous, indeed:

tahua, sun; C: tabih, tabikan; Shosh: tava.
muiyane, moon; Kizh: mōār; C: mea, crescent.
ŭmuegi, thunder; C: tomoyake.
koltsa, white; C: tochtsa.
mŭ-u, pron. *I;* C: un.
gai, no; C: kai.
ŭtŭliŭ-ŭ, hot; C: urate.
vuete, woman; C: víepe.
pushi, eye; C: pui; Shosh: pui.
dama, teeth; C: tama.
makhde, hand; C: mash-pa.
shuki, nails; Com: (techtse=) tsuke.

Terms equivalent and related to Kiowa words are also very numerous and important and are not at the same time related to Comanche:

taka, young, boy; K: tuquois.
ŭngva, blood; K: um.
And the terms for friend, morning, arm, belly, day, wind, duck, three, thou.

With the Yuma dialects, Moqui agrees in the following terms:

gaskavi, yellow; Cuchan: aquesque; Goh: kuase.
vue pa, large, great; Goh: ve'te.
shuki, nails; Goh: sha-la-huó, (la, hand.)
shehevi, green; Goh: ilvi.

We also discover congruencies with the following works from the Apache dialects, which form the southern branch of the Athapascan or Tinnē family of languages:

tsi-i, bird; Nav: tsiti; Teh: tchi-e; Ap: tchisuki, crow.
shohe, stav; Nav: sō; Ap: ssōs; Kizh: surn.
bibe, female breasts; Nav: be; Ap: ibit; Com: pítsi.
makhde, hand; Ap: la, lda, n-'la, latā.
tchaio, small; Nav: alt chisi.

Affinities with Jemes are found in:

peshe, valley; J: peta.
tŭtŭkvi, mountain; J: tota.
kvohe, wood; J: kviē; Isl: ka-i.

Affinities with Tehua we discover in the following words:

aba, buffalo lodge; Teh: bá'-.
tevaē, pine tree; Teh I: ta-u, ta-au.
gā'-ē, Indian corn; Teh I: ko-ote.
lengi, tongue; Teh: heng, (perhaps Spanish.)
makhde, hand; ma-ata', arm; Teh: mā, mang.
tahua, sun; Teh: tang, tan; Tesuque: tā.
kucuē, coyote; Teh: koyo; Aztec: coyotl.
kvahŭ, wing; Teh: kŭkŭ.
kokala, strong; Teh: akiele.

To these we may add some personal pronouns, the numeral *three*, and a few words mentioned above. The large number of Tehua words admitted into Moqui explains itself readily by the presence of a Tehua village on one of the eastern Moqui mesas. To these reference was made by Francesco Garces in 1775, when he averred the existence of "two nations and two different tongues in the Moqui pueblo," (Buschmann, Pima Language, p. 323.)

I conclude by mentioning some similarities between Moqui and the Zuñi language:

kiú, water; Z: kíave.
tótché, ice; Z: 'tchathle.
tŭvua, earth, land; Z: sóvi.
shikvi, meat; Z: shíle.
tchaio, small; Z: tsánna.
ovin, yes; Z: aiai.
páhio, three; Z: hŭbi.
nina, to kill; Z: aÿina.

Moqui is found to agree with Otomí (Mexico) in terms, as gŭgŭ, foot; Ot: gua nagviya, warrior; Ot: magagui, war; with Palin (Central America) in uénangva, heart; P: vuanuma; koltsa, white; P: sak.

Many of the word-resemblances quoted in the preceding pages are perhaps uncertain,

fortuitous, and not based on real affinity. They cannot be thoroughly verified and sifted before we possess a sufficiency of reliable material, good grammars, and copious, accurate dictionaries of all these languages. The conclusions which can be safely drawn on the origin of the Pueblo Indians, from a purely linguistic standpoint, and an accurate scientific study of the material presently available, may be summed up in the following items:

1. The four groups of Pueblo languages in New Mexico and Arizona are languages originally independent of each other.

2. The three first groups do not show any marked and convincing affinities to other aboriginal tongues, although they have borrowed extensively from Athapascan, Yuma, and Shoshone languages. The fourth, or Moqui tongue, is so largely interwoven with Comanche and Kiowa words that a common origin must be admitted.

3. Affinities exist with the Dakota, Aztec, and Central American tongues; but they are too scanty to prove a common origin. The important affinities which all Pueblo vocabularies show with Kiowa, each of them in different words, prove that the Kiowas are a medley of roving tribes and Pueblo Indians, who probably gathered around a Comanche stock, and recruited themselves from other hunting tribes in whose vicinity they roved.

4. The polysyllabic nature of the Zuñi words and their quinary counting system differ entirely from what we see in other Pueblo languages, and prompt us to look out for a distant, perhaps southern, relationship of this interesting tribe.

The momentous problem, "Which countries have included the former seats of the Pueblo tribes prior to their settling down in the valley of the Rio Grande and the adjacent deserts?" cannnot, we think, be solved from purely linguistic data or apparent word-affinities. Archeology and ethnology are more apt to remove the veil which envelopes this mystery, for it can probably be cleared up only by a careful study of the migrations of the other American tribes. Linguistic researches seem to be in favor of a southern origin.

Respectfully submitted.

ALB. S. GATSCHET.

Lieut. GEO. M. WHEELER,
Corps of Engineers.

APPENDIX K.

PUBLICATIONS, MAPS, REPORTS, PHOTOGRAPHS.

MAPS.

At the close of the past fiscal year, a 2,000-copy photolithographic edition of the Topographical Atlas Sheets Nos. 50, 58, 59, and 66, together with several preliminary sheets, had been issued. All of this edition has been distributed during the year. A second 2,000-copy photolithographic edition of the same sheets has been ordered, increased by sheets Nos. 49, 57, 65, and 67. Authority has been granted and contracts executed for a 2,000-copy photolithographic edition of ten additional atlas-sheets; three upon a scale of 1 inch to 8 miles, the remainder to a scale of 1 inch to 4 miles. Proofs have been received of Atlas Sheets 50, 58, 59, and 66, executed by the crayon-process at the establishment under Mr. Julius Bien, New York City, and contracts entered into for Sheets 49 and 67, making a set of six connected sheets thus represented.

Proof-sheets of four of the Geological Atlas Maps have been received, based upon such of the published Topographical Sheets as have been sufficiently surveyed geologically to warrant publication, and during the year originals of Sheets 49, 67, 75, and 83 have been added. The Lake Bonneville Chart is also in hand and approaches publication.

The following topographical maps are in course of completion, or completed: On a scale of 1 inch to 8 miles, Nos. 75, 76, 83, and portions of 77 and 84; on a scale of 1 inch to 4 miles, Nos. 52 (D), 53 (C), 61 (B), (C), and (D), 62 (A) and (C), 69 (A), (B), (C), and (D), 70 (A) and (C); also, a special map of the San Juan mining region, in Southwestern Colorado, upon a scale of 1 inch to 2 miles.

The geographical work of the season of 1875 will comprise those portions of Nos. 77 (B) and (D), 78 (A) and (C), 72 (B) and (D), and 73 (A), (B), (C), and (D), that can be completely surveyed during the year; and, by the special party sent to the valley of the Colorado, detailed topography, approaching its banks from near the foot of the "Grand Cañon" to the "Needles," will be observed.

There is a steadily-growing appreciation of the value of accurate geographical information of sections of country even so remote from the present loci of settlements as those visited by the several expeditions in my charge, evinced by the repeatedly-increasing calls for maps and other publications of the survey. That the want of such accurate information will lead to further and more extensive application of the geo-

graphical results of the survey is not to be doubted, while each new geographical fact added, from year to year, is an increase to that common stock of knowledge that may finally be valuable to any and all human activity, and in which everybody is or should be interested.

REPORTS.

Since my last annual report the following special reports have appeared:

1. Preliminary Report of reconnaissance in Southern Nevada in 1869.
2. Progress report of 1872.
3. Report upon the Vertebrata of the Eocene of New Mexico.
4. Preliminary report upon the collection of invertebrate Fossils, for 1871, 1872, and 1873.

By act of June 23, 1874, $25,000 was appropriated for engraving and printing the plates to illustrate the quarto volumes recommended in annual report for 1873 as the form for the expression of the matured results of the survey.

By an amendment to the above act, approved February 15, 1875, the number of copies of each of the six volumes authorized by Congress to be published for the use of the War Department was two thousand.

The MS. of two of these volumes, viz, Vol. III (Geology) and Vol. V, (Zoology,) has gone forward to the Government Printer.

The greater part of the MS. of Vol. II (Astronomy and Meteorology) is ready; of Vol. IV, (Paleontology,) the report upon invertebrates is complete, and that upon vertebrates is well advanced. Vol. VI (Botany) will be delayed, to embrace the results of the season of 1875. Vol. I is well advanced. The many plate-illustrations for these reports are in the hands of the lithographers. A catalogue of mean declinations of stars from 10° to 80° north declination, and for use in the determination of latitudes between the limits of 20° and 50° north latitude, is approaching completion in the hands of Prof. T. H. Safford.

The only special report suggested for publication at an early date within the approaching fiscal year will comprise a collation of data giving routes, distances, geographical positions, altitudes, &c., over large areas in Colorado, New Mexico, Arizona, Utah, Nevada, and California.

The following maps and reports pertaining to the survey have been published since its inception:

MAPS.

Preliminary map to accompany 1869 Report.
Preliminary map to accompany 1871 Report.
Skeleton map to accompany Progress Report for 1872.
Progress map to accompany annual report for 1873.
Progress map to accompany annual report for 1874.
General Topographical Map, Index Map, Basin Map, Sheet of Conventional Signs, Legend Sheet, Atlas Sheets 49, 50, 57, 58, 59, 65, 66, 67, Crayon Atlas Sheets 50, 58, 59, 66, Geological Sheets 50, 58, 59, and 66.

REPORTS.

Preliminary Report, 1869; Preliminary Report, 1871; Camp Distances, 1871; Camp Distances, 1872; Progress Report, 1872; Astronomical Report, 1873; Annotated list of the birds of Utah, 1873; on the Plagopterinæ and Ichthyology of Utah, 1873; Astronomical Report, 1873; Catalogue of Plants, 1874; Report upon Ornithological Specimens, 1874; Report upon Vertebrate Fossils discovered in New Mexico, with description of new species, 1874; Preliminary Report upon Invertebrate Fossils, 1874; Systematic Catalogue of Vertebrata of the Eocene of New Mexico, 1875.

PHOTOGRAPHS.

A few selected stereoscopic and landscape photographic subjects have been printed during the year for the use of the War Department, Engineer Bureau, and this Office.

Since valuable material embodying a description and partial history of the ancient and present aboriginal tribes of the southwestern portion of the United States has been and is still being gathered. I have the honor to recommend that a seventh quarto volume be authorized to be devoted to the subjects of archæology, ethnology, and philology. In order to carry out the projects contemplated in the publication of maps and reports for the ensuing fiscal year, I have the honor to recommend that an appropriation of $25,000 be asked.

The probable distribution of the same will be as follows:

For preparation and engraving and printing topographical atlas sheets ..	$12,500 00
For preparation, engraving, and printing geological atlas sheets.........	5,000 00
For preparation, engraving, and printing of plate, photographic, and other illustrations	7,500 00
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